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ORIGINAL ARTICLES.

I.—Geology of the London Extension of the Manchester, Sheffield, and Lincolnshire Railway. Part I: Annesley to Rugby.

By C. Fox-Strangways, F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

THIS portion of the new trunk line to London covers a distance of about fifty miles, and runs nearly due south, crossing the towns of Nottingham, Loughborough, Leicester, Lutterworth, and Rugby. Throughout the greater part of this distance the railway is on the Trias, except the northern portion, which is on the Permian, and the southern, which is on the Lias. There are also great thicknesses of Drift met with near Leicester and between that town and Rugby, but very little in the northern part on either side of Nottingham.

Commencing at Annesley, the first section, which is just east of the Midland station, shows the lower sandstones of the Trias overlain by a little sand and gravel. This sandstone is not here of any great thickness, as in the shallow depressions on either side the Permian Marls crop out and may be followed along the next cutting to the south. At the south end of this cutting a fault is crossed which brings in the Magnesian Limestone. The railway is continued over this formation for some distance beyond Linby, but being carried on a high embankment the rock is only exposed here and there in the ditch along the side. The sections, however, show that there is not much superficial covering over this comparatively flat ground.

As we approach Hucknall Torkard there is a marl cutting, but the limestone soon rises up from below. This latter is much disturbed by a fault or sharp roll near the bridges at the north end of the town, some of the beds being quite vertical. The same disturbance was noted in the culvert over the brook a little to the south. A drawing of this was made by Mr. Allen, the resident engineer of this portion of the line.[1]

[1] I am greatly indebted to Mr. Edward Parry and the resident engineers of the different sections of the line for much information as to the nature and thickness of the strata met with in the excavations for bridges and other structures, which were covered up before the time of my visit.

In the large cutting west of Hucknall Torkard the marls repose on the Magnesian Limestone, the whole being surmounted by about six feet of pebbly clay; but the section was not cut to its full depth at the time of my visit. At the south end the limestone is again much disturbed, and dips to the south-east at an angle of 15°, passing under the marls. There is no doubt that the stratification here is much more broken up than shown on the old geological map, and that a good deal more marl crops out than is represented there.

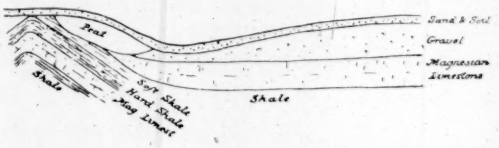


Fig. 1.—Section in culvert north of Lambert Hill, Hucknall Torkard. Copied from a drawing by Mr. Allen.

Several cuttings in marl were observed between this spot and the Leen valley, where the Permian beds pass beneath the Trias. Over this ground there also appears to be a certain amount of pebbly gravel; but, from the railway-section alone, it is not clear of how much importance these deposits are.

At Bulwell the line crosses the Leen valley by a lofty viaduct, the excavations for the piers of which exposed sections in marl and limestone on the west side of the Midland Railway, and in sandstone on the east side.

The line now enters the Trias, the sandstones of the Pebble Beds being exposed in several fine cuttings between here and Nottingham, beneath which town it is carried in a series of tunnels that were easily excavated in these soft false-bedded sandstones.

On the south side of Nottingham the piers for the bridge over the Trent were sunk through from 10 to 12 feet of river gravel on to the Bunter Sandstone, and showed that the latter was more eroded on the southern side than on the northern, the solid rock being reached at 57 feet above ordnance datum on the northern side, while it was 52·5 feet at the south abutment.

After crossing the broad expanse of the Trent Alluvium at Wilford the line enters a deep cutting in the marls of the Keuper series, and there is a good section of the band of sandstone that is shown on the old geological map dipping at 2° to the south-east. Towards the southern end of this cutting the marl is overlain by about 8 feet of sand and gravel, which appear to be banked along the foot of the hill.

At Ruddington the line crosses a depression in the marl filled with sand under about 3 feet of dark peaty soil which extends past the station. This hollow has evidently been an old swamp similar to the larger one at Gotham alluded to below. At the side of the railway here is the boring which has been recently carried to a depth of 1873 feet; this boring beneath 684 feet of Trias penetrated over 400 feet of strata, supposed to represent the lower portion of

the Derbyshire Coal-measures. These were found resting on coarse grits and sandstones, probably the equivalent of the Millstone Grit.[1] South of Ruddington station there is a cutting showing from 3 to 12 feet of sand and chalky gravel, with pockets or pipes of clay overlying the marl. Beyond this the line crosses Gotham Moor, where numerous small excavations show about a foot of peaty soil over sand and gravel. It is evident that this extensive flat, which stretches from Gotham to Bunny, a distance of about three miles, was formerly a swamp or possibly a shallow lake. On the south side the ground rises in the long ridge formed by the Rhætic beds and the lowest part of the Lias; but the line passing in the hollow between the outlier of these beds and the main mass, there is no section in them, and only some whitish-grey or tea-green marls are seen reposing on Red Keuper Marl.

Opposite East Leake there is a deep cutting showing tea-green marl beneath Drift deposits, the latter consisting of sand and gravel beneath a Boulder-clay, in which there are many well-rounded pebbles of quartz and fragments of Keuper Sandstone, but very few boulders of any size. With the exception of the doubtful gravels at Ruddington, it will be observed that this is the first really glacial section that we have come to; but to the south of Loughborough they become more common and are of greater importance.

South of Leake the railway cuts through the narrow ridge of Lias and Rhætic forming Normanton Hills, and a very interesting section is exhibited in these beds. The summit of the ridge is crossed by a short tunnel, on the north side of which is a deep cut in grey or tea-green marls surmounted by about 20 feet of dark, finely laminated shales. At the junction of these there is a yellow band about 6 inches thick, but there is no bone-bed, or if there is it must be in a very fragmentary condition.[2] The beds dip at 6° to the south, and are let down against the Red Marl to the north by a fault which is seen within a few yards of the end of the cutting. South of the tunnel the lower part of the Lias comes on rather rapidly with a dip increasing from 2° to 6°. The beds, which constitute the *Planorbis*-zone, consist of the usual alternations of shales and bands of limestone with a thick bed of shale at the bottom resting on a band of nodules.

Section at Normanton Hills.

	ft.	in.
Thin band of limestone Shale Thin band of limestone Shale	About 2 or 3 feet, but much broken up and weathered.	
Band of limestone	0	8
Shale	2	0
Band of limestone	8	0

[1] G. E. Coke: Trans. Fed. Inst. Mining Eng. 1896; Proc. Geol. Assoc., vol. xiv. p. 430.

[2] Mr. Montagu Browne gives a short but detailed account of this section – Report of the Brit. Assoc. for 1895.

	ft.	in.
Shale	3	0
Band of limestone	0	4
Shale	1	0
Sandy shale	0	10
Limestone full of *Ostrea*	0	7
Sandy limestone and shale	1	6
Shale	0	6
Band of limestone	0	8
Shale	0	8
Band of limestone	0	10
Shale	13	0
Band of nodular limestone	0	10

Towards the southern end these beds turn up rapidly at an angle increasing from 10° to 25°, until at 140 yards from the centre of the road over the tunnel the great east-and-west fault is crossed which brings in the red marls of the Keuper. The Diagram gives the general appearance of this section (Fig. 2).

From this point the line continues on red marl as far as the River Soar opposite Loughborough, passing through a deep cutting in marl with a band of sandstone 3 feet thick dipping to the north at the low angle of from 1° to 2°. The northern end of this cutting is formed of Boulder-clay resting on sands and gravel. The former contains quartzite pebbles and fragments of sandstone and Lias, some of which are of considerable size and generally striated. The gravel is composed mostly of quartzite pebbles, and occurs in pockets or irregular patches in the sand. This drift comes about to the bottom of the cutting on the north side, but thins out near the summit of the hill; showing that it does not cap the hill in the usual manner, but is deposited against its northern and western flank, as we shall show is the case in some of the sections further south.

In crossing the valley of the Soar the alluvium was found to vary from about 15 to 19 feet in thickness, and consisted of the following subdivisions[1]:—

	ft.	in.
Soil	2	6
Loam and clay	6	0
River gravel	7 to 10	0

The thickest gravels were met with at the north end of the viaduct, and near the centre; which spots probably mark the position of old bends in the river. At the Nottingham Road, at the Midland Railway, and at the Canal the marl was reached at 8, 14, and 12 feet respectively.

At Loughborough the line crosses a terrace of chalk gravel, which extends for some miles on this side of the Soar valley, as will be shown in the new edition of the Geological Survey Map. This terrace is about twenty feet above the modern alluvium of the river: the gravel, which has an average thickness of ten feet or more, is composed mainly of chalk flints and quartzite pebbles; it is

[1] From information supplied by the resident engineer, Mr. F. D. Sharp.

probably derived from the Chalky Boulder-clay further up the valley. This gravel is continued along the railway with some intermissions as far as Quorn Lodge, where it gets thinner and becomes mingled with Boulder-clay and earlier gravels, so that the sections are rather obscure. In fact, the cuttings about here show how difficult it is to separate gravels which are of late Glacial age from those which are Post-Glacial. One section showed contorted beds of clay and sand, but its relation to the gravel was not clear. From the general aspect of these sections I am inclined to think that the terraces must have been begun to be laid down immediately after the later Glacial beds, and while a little ice was still lingering in these valleys.

After crossing the little valley west of Quorndon, the railway continues in Keuper Marl until we reach the hill west of the new reservoir at Rusheyfields Lane. Here there was a deep section in Boulder-clay, but the greater part had been sloped down before I saw it. The north end of the cutting, however, was exposed, and showed about six feet of sand, loamy in part, with a little pebbly gravel at the bottom resting on Boulder-clay, with many large Lias fragments, and a few granite and Carboniferous Limestone blocks, many of the boulders, especially the Lias fragments, being striated. No chalk fragments were observed here, although they are plentiful on the opposite side of the valley at the foot of Buddon Wood and in the branch line which is being taken to Mountsorrel quarries. In this branch line there is a good section of the Chalky Boulder-clay, which at the northern end near Hawcliff Hill is seen reposing on Boulder-clay without any chalk, there being at places a little sand between the two. Nearer Nunckley Hill the Chalky Boulder-clay rests directly on the Keuper Marl, the Lower Boulder-clay having thinned out in this direction. The Chalky Boulder-clay here contains many Lias and granite boulders.

At Nunckley Hill the branch railway cuts through a boss of granite, the junction with the overlying beds being, as usual, very steep. On the eastern side the Boulder-clay rests on

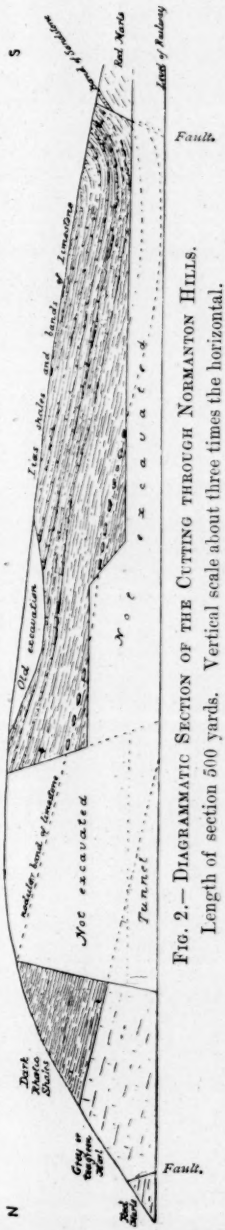


Fig. 2.—Diagrammatic Section of the Cutting through Normanton Hills.
Length of section 500 yards. Vertical scale about three times the horizontal.

the granite; but on the western side the Red Marl is seen abutting against the granite, large blocks of the latter being included in the marl as if they had fallen from a cliff during its deposition. The main railway also just touches the granite of Brazil Wood, but there is no section of the rock;[1] the piers of the viaduct, however, are sunk in Keuper Marl, showing again how steep the junction is between these two formations.

After crossing the road to Swithland, the line enters some thick beds of gravel and sand, which underlie the great spread of Chalky Boulder-clay forming Rothley Plain. This sand, which is stratified, contains numerous isolated boulders of granite, many of which are of considerable size, but there do not appear to be any other stones in the main mass of the sand, nor any clay. The appearance of these great boulders sticking out in the sand is most remarkable, and how they got there is a curious problem. Possibly they are evidence of a granite cliff in the immediate neighbourhood; the absence of any clay seems to preclude them from being due to glacial action. At the summit of the hill these sands pass beneath a thin covering of Boulder-clay, and at the bridge under the road to Rothley terminate very abruptly against a bank of Keuper Marl, another instance showing how these drifts seem to be banked against the northern sides of the hills.[2]

On the opposite side of the Rothley valley the line passes through a deep cutting in Boulder-clay, which is mainly composed of Lias with quartzite pebbles and some chalk fragments. It also contains irregular patches of sand and gravel, but no beds of any thickness. This same Boulder-clay, which, however, becomes more chalky, continues for about two miles to the neighbourhood of Birstall. Here at the back of Cliff Lodge the Boulder-clay contains masses of very coarse gravel composed mostly of Lias and Oolite, which has been pushed into a series of undulations between masses of Boulder-clay, evidently showing some disturbing force subsequent to its deposition. At Birstall Hill Park a thick bed of sand and gravel comes out from beneath the Boulder-clay, and, rising to the south, soon occupies the whole of the cutting, forming one of the finest sections of false-bedded sands and gravel to be seen along this part of the railway. There is not much doubt that this sand is part of the bed which occurs at the base of the Boulder-clay in this country, and which has been traced almost uninterruptedly along this side of the Soar valley; but its position here is rather abnormal, being considerably above the usual level of these sands. Before the cutting was made there was very little evidence at the surface of so large a deposit of sand and gravel.[3]

[1] A short account of the rocks near here is given by Mr. W. W. Watts: Trans. Leicester Lit. and Phil. Soc., vol. iv, p. 12, 1895; and Proc. Geol. Assoc., vol. xiv, p. 432.

[2] At this spot some supposed British remains have been found by Mr. W. T. Tucker, who gives a beautifully illustrated account of them in the Trans. Leicester Lit. and Phil. Soc., vol. iv, p. 212, 1896.

[3] Mr. Montagu Browne, F.G.S., has some fine photographs of these gravels.

At the southern end of this cutting just above the Belgrave Cemetery there is an opening in the usual Lower Boulder-clay of the district composed of Lias and other local rocks without any chalk fragments.

The railway crosses the Mowmacre Road on a lofty embankment, the foundations of the bridge showing a very steep boundary to the Keuper Marl at the side of the valley, the south abutment being against the marl, while the northern one was sunk 16 feet in loamy sand without reaching the bottom of it.

In the next cutting the lower non-chalky Boulder-clay was found in the foundations of the bridge over the path to Stocking Farm. A little further on there is a section in the clays and gravels above, which is interesting from the close similarity of one of the bands to certain beds in the Coal-measures; leading one to the idea that, although these beds were formed under very different circumstances, some of the conditions may have been somewhat similar. The clay, which was somewhat of the nature of "clunch," that is, a firm marly clay without much stratification, contains lines of incipient concretions, which appear to be in process of formation. The following sketch will show the relations of the beds more clearly :—

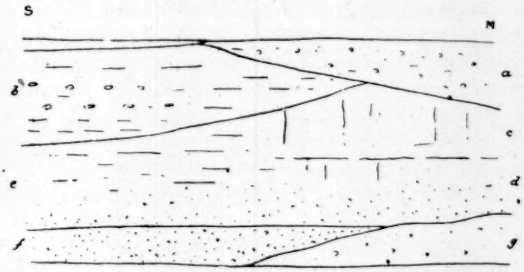


Fig. 3.—Cutting S.E. of Stocking Farm, near Leicester.

(*a*) 4 ft. Weathered Boulder-clay with scattered chalk flints. (*b*) 6 ft. Irregular, lumpy, soft, marly beds, and clay with incipient concretions. Has very much the appearance of unconsolidated Coal-measure clay. (*c*) 3 ft. Stiff dark clay. (*d*) 3 ft. 6 in. Loamy sand. (*e*) 5 ft. Sand and loam with marly partings containing race. Passes into dark brickearth and drab clay towards the north. (*f*) 2 ft. Chalky gravel. (*g*) 3 ft. Gravelly, chalky Boulder-clay.

The sand and gravel at the base crops out on the side of the hill, and is continuous with the general outcrop of these beds throughout the district.

After crossing the little valley leading up to Beaumont Leys, which is on Keuper Marl, the line traverses the extensive plateau of gravel on which Leicester Abbey stands, and which fringes the river Soar at this point. In crossing the river the Red Marl was found at a depth of a little over 10 feet, but further on, between the river and canal at Slater Street, the depth was over 18 feet, showing that the old course of the river must have formerly been further south at this point.

Through the courtesy of Mr. Chalcraft, the resident engineer of

this portion of the line, we have obtained a large number of sections in the town of Leicester. These seem to show that the rise of the ground to the south of Soar Lane, although based upon marl, is mainly caused by the great accumulation of made ground which occupies the site of the old Roman city. This deposit is in many cases fully equal to the rise of the ground ; in Bath Lane it appears to sink below the level of the river, showing that the contour of the ground and probably the position of the stream have altered considerably since Roman times.

After again crossing the river at West Bridge the railway continues for some distance over the alluvium, which was found to be of varying depth up to 20 feet at St. Augustine Street. On the west side of the Bede House Meadow the foundations of the viaduct showed that this alluvium rests abruptly against a steep bank of Red Marl. Entering a cutting of Red Marl we find at its southern end an equally abrupt termination, a terrace of sand and chalk gravel being banked against the marl. This same gravel is seen again under the Burton branch of the Midland Railway, where it is also banked against marls to the south; but is partially overlain by dirty gravel and sand, which evidently belong to the Glacial beds. The section appears to show that the drift gravel is more recent than the banked terrace below, but this is probably not the case, and as the gravel does not extend far it may have slipped over the edge of the terrace. Further on in this cutting, just beyond St. Mary's Mills, there is a thick deposit of cemented gravel, which has aroused a good deal of local interest and speculation as to the source of the cement, although such gravels are really not at all uncommon. They are excessively hard, and have given the contractor a good deal of trouble to excavate.

The line now for the fourth time crosses the Soar valley, the alluvium of which was found to be from 6 to 12 feet thick. South of Aylestone there are cuttings showing from 8 to 20 feet of local drift composed chiefly of Lias and Keuper fragments with pebbles and a few granite boulders. This is surmounted by chalky clay in the deeper cuttings, but there is evidently a good deal of the non-chalky clay about here.

In sinking for the piers of the viaduct across the valley at Whetstone, there was found to be 10 feet of alluvium. Beyond this the railway is carried on a lofty embankment past the villages of Whetstone and Cosby, a distance of over two miles, before there are sections of any note. In crossing the Midland Railway at Cosby, which runs in a deepish cutting, the Boulder-clay was found to extend to the base of the foundations some depth below the rails, so that it is evident the drift must be of considerable thickness about here. This also is shown by the series of deep cuttings that are continued for some distance to the south, and in none of which the solid rock was reached.

In the cutting under the Lutterworth Road the Boulder-clay rests on sand; which, rising to the south, forms a considerable outcrop, but along the railway is soon succeeded by stiff, chalky, and local

Boulder-clay. About a mile further south this Boulder-clay is seen to be roughly interstratified with beds of sand and warpy clay which run down towards the north.

On approaching Dunton Basset we come to one of the deepest cuttings in this part of the line, but from the sloping down of the banks as the work was being carried on it was not easy to see the exact relationship of the beds. At the northern end, however, near the road to Ashby Magna, there is an extensive outcrop of sand, which is banked against or rests on the Boulder-clay further south. This Boulder-clay is of the usual chalky character, but is remarkable from its containing a large mass of Middle Lias limestone crammed full of *Rhynchonella*, which measured 12 feet across, and of which 12 feet were exposed above the rails; how far it may have extended in the other directions could not be seen. At the tunnel under the road there is a fine section showing about 35 feet of yellowish Boulder-clay resting on 13 feet of sand and gravel. This gravel, which dips to the north, is better exposed on the south side of the tunnel, where it crops out and is seen to be succeeded by a band of clay and then more sands and gravels. These gravels are very irregularly stratified, and are composed mostly of chalk flints and pebbles. They must have a considerable thickness just here; and, including the band of clay, cannot be less than 50 feet or more.

At Cotes de Val 19 feet of a very hard chalky Boulder-clay were proved in the foundations of the bridge, and at the next bridge crossing the road to Gilmorton there were 17 feet of gravel, showing that there are many variations in the beds, but the cuttings do not throw any light on their relation. This chalky clay, which contains a great quantity of Lias and sandstone boulders, as well as a few Carboniferous limestones, extends all the way to Lutterworth, where we reach another great deposit of stratified sand and gravel. These gravels have been proved to a depth of 40 feet; they contain bands of chalky clay, and appear to abut against the Boulder-clay on the west in a somewhat abrupt manner.

The foundations of the bridge over the stream at Lutterworth are sunk through 10 feet of alluvium into beds of grey shaly Lias limestone. I could find no fossils in this limestone, so am unable to say what horizon has been struck here; but the section is interesting, as this is the only point at which the underlying rocks have been met with between the Soar valley at Whetstone and the Avon at Rugby.

At the road just south of this bridge 2 feet 6 inches of "Red Marl" was found over 15 feet of sand. I did not see this section, but Mr. Collinson, the resident engineer, states that it was exactly like Keuper Marl; if so, it must have been a drifted mass. Above this comes a Boulder-clay with seams of sand, and at the top of the hill about 15 feet of gravel and loam with many chalk fragments, and a few large Jurassic boulders. South of Lutterworth there are shallow cuttings in Chalky Boulder-clay with a little sand and gravel here and there for a distance of two miles, but no sections of any importance. At Shawell the cutting shows stiff blue

Boulder-clay, with Lias and Chalk fragments resting on sands and coarse gravels, which crop out to the south, but run down under the Boulder-clay towards the north. The junction between the two is very irregular, the sand forming arches beneath the clay.

After crossing the Watling Street the line enters a thick deposit of chalky gravel and sand, which is partly cemented into a hard conglomerate similar to that mentioned above near Aylestone. This conglomerate must be fairly extensive about here, as it has been met with in a series of trial borings on the other side of the valley near the Watling Street. In the deeper part of the cutting near Newton this gravel is overlain by about 20 feet of grey Liassic Boulder-clay, which appears to turn into coarse gravel at the southern end. The outcrop of the gravel is very clear about here, and there is a sharp junction with an underlying Boulder-clay. In the cutting due east of Newton House another large boulder has been touched; it consists of a mass of yellow Oolitic limestone 15 yards in length.[1] The Boulder-clay also contains a curious ball of sand, which is concentrically stained and looks very similar to a concretion in harder rocks. Between this point and Rugby the line keeps on Chalky Boulder-clay, but there are no sections of any importance.

In crossing the valley of the Avon opposite Rugby station the blue Lias clay was found at a depth varying from 5 to 17 feet below the surface of the alluvium, and showing three or four depressions where the old streams have hollowed out channels in the solid formation. The deepest part of the old valley appears to correspond with the present course of the River Avon; but there is another deep channel 530 yards to the south of this, and 250 yards south of the present Clifton Brook.[2] The alluvium consists mainly of clay and loam, except towards the southern side, where there is a considerable amount of gravel, 15 feet 6 inches in one of the excavations.

On the south side of this valley the line cuts into the great plateau of gravel and sand upon which Rugby stands, and which has a maximum thickness of 22 feet, but in some places is not more than 3 feet thick. These gravels are of a fairly uniform character; they extend to the brow of the hill just beyond the Dunchurch and Hilmorton Road, where they form a sharp bank overlooking the Lias valley beyond. They appear to rest directly on the Lias shales below throughout the greater part of the cutting; but whether a Boulder-clay intervenes in some places was not clear, as a great part of the ground had been sloped down. From these shales the following species, which have been determined by Mr. E. T. Newton, were obtained: *Ammonites obsoletus*, Simp, *Am. bifer*, Quenst., *Am. trivialis*, Simp., *Am. curvicornis?* Schlön., *Belemnites breviformis*, Voltz., and *Nautilus*.

[1] This is only about a mile from Brownsover, where something of the same character was met with by Mr. J. M. Wilson.—Quart. Journ. Geol. Soc., vol. xxxi, p. 355.

[2] From information supplied by Mr. A. W. H. Carson, the resident engineer.

These seem to show that the beds here belong to the *Oxynotus* or *Armatus* zones.

South of this great cutting the line runs on an embankment for some distance, and there are no exposures till we get to Willoughby; from which point southwards the sections have been examined by Mr. H. B. Woodward, and will be described by him in the second part of this paper.

II.—On the Age of the Morte Slate Fossils.

By J. W. Gregory, D.Sc., F.G.S.

As the discussion at the Geological Society on Dr. Hicks' paper "On the Morte Slates and Associated Beds in North Devon and West Somerset" (Quart. Journ. Geol. Soc., vol. lii, pp. 254–272, pls. x, xi) showed that the case for the Silurian age of those beds rested mainly on the palæontological evidence, I examined the more important fossils somewhat carefully at the close of the meeting. I had a perfectly open mind as to the age of the fauna, for a couple of visits to North Devon and West Somerset had given me the impression that pre-Devonian beds might be hidden in the eastern part of the area. As a paper recently read to the Geological Society of Cornwall assumes the Silurian age of the Morte Slates to be so well established that it may be accepted as the basis for future work, I have been led to re-examine the evidence by a comparison of Dr. Hicks' descriptions and Mr. Michael's figures of the fossils and my notes about them.

The palæontological section of Dr. Hicks' paper enumerates eight species, while another name is added in the explanation of the plates. Of the nine species four are described as new, and five are identified as Silurian species; but in three cases the identification is queried, leaving only two species certainly claimed as Silurian.

The evidence of six of the nine species does not seem to me to be worth much. Two of the new species belong to genera having so wide a range as *Lingula* and *Spirifera*, and thus their evidence as to the age of the rock in which they occur is not very weighty. The occurrence of *Cardiola interrupta*, Sow., in the Morte Slates rests apparently on a few shell fragments, which unquestionably came from some bivalved animal, and probably from a lamellibranch. But the ornamentation shown in the specimen figured (Hicks, op. cit., pl. xi, fig. 19) agrees so closely with that of some Devonian species of *Pterinopecten* and *Aviculopecten*, that the material is quite insufficient to determine the family to which the fragments belong. In the case of the specimens figured as *Rhynchonella Lewisi*?, Sow., *Rhynchonella Stricklandi*?, Sow., and *Orthis rustica*, Sow., the specimens figured have a resemblance to the species named; but they are also very similar to Devonian species, and Dr. Hicks' queries after the names of the two first show that no great stress can be laid upon them. The identification of *Orthis rustica* is apparently based on the ornamentation; but the plan of ribbing quoted as "one of the chief characteristics of *Orthis rustica*" occurs also in the Devonian *Orthis interlineata* and in other species.

Without the opportunity for a careful study of a considerable series of specimens in various conditions of distortion, the specific determination of crushed specimens of *Rhynchonella* and *Orthis* is not a task lightly to be undertaken. I was accordingly more interested in the generic determination of the three remaining species.

The species named *Pterinæa Mortensis* is interesting as containing the most recognizable fossils in the collection. Of the two specimens figured, that illustrated by pl. xi, fig. 16 seems to me the better. Its umbo is situated at $\frac{5}{13}$ of the length of the hinge-line from the anterior end; in *Pterinæa* the umbo is much more forward, occurring at about only half that distance from the anterior end. Thus, taking the distance of the umbo from that point at 1, then in six casually chosen species of *Pterinæa* the length of the hinge-line would be as follows: 4·1, 4·4, 5, 5·1, 5·4, and 6·1. In Dr. Hicks' two species the length of the hinge-line would be 2·17 and 2·6.

Moreover, the umbo of Dr. Hicks' specimens are higher than in *Pterinæa*, and the form of the shell is pectinoid, rather than having the trigonal shape of *Pterinæa*. All the known characters of Dr. Hicks' new species seem to me to indicate that the fossils should be removed from the family Pteriniidæ, and included in the genus *Aviculopecten*. Taking ten species of that genus at random, the relation of the position of the umbo to the length of the hinge-lines varies from 1·9 to 2·5; the figures are as follows: 1·9, 1·9, 1·94, 2·02, 2·15, 2·17, 2·18, 2·25, 2·3, and 2·5. The fact that Dr. Hicks' specimens agree in this important character with *Aviculopecten* rather than with *Pterinæa*, may be regarded as due to the distortion of the specimens. This argument might be applied to the specimen shown on pl. xi, fig. 17, but in the case of the other (fig. 16) the fossil has only been somewhat lengthened; and as the lengthening has been uniform, this could not have altered the relative position of the umbo on the hinge-line. The genus *Pterinæa* occurs both in the Silurian and Devonian systems; but *Aviculopecten* is typically Upper Palæozoic.

In the next species, *Modiolopsis Barricanensis*, Hicks, the generic determination is again the important point. The species is said to approach most nearly to the Silurian *Modiolopsis subalata*, Hall; but the resemblance between the two species does not seem to me very striking, and, in fact, I doubt if they belong to the same genus.

There are two specimens figured as belonging to this species; that shown on fig. 15 is too young for determination by itself, but the other specimen is more instructive. It is probably a member of the family Modiolopsidæ; but all doubt on this point cannot be removed without further exposure of the anterior margin of the shell. Assuming that it is one of the Modiolopsidæ, it seems to me to belong to *Modiomorpha* rather than to *Modiolopsis*. The distinction of the two genera rests on the dentition, which cannot be seen in either specimen; the affinities of the species can therefore only be provisionally determined by comparing its form with that of the variations seen in the two genera. The larger specimen of Dr. Hicks'

new species agrees fairly closely with the Devonian species *Modiomorpha subalata* (Conr.); and the probabilities seem to be that if the dentition be ever determined, the fossil will be found to belong to the Devonian genus *Modiomorpha* rather than to the typically Silurian genus *Modiolopsis*.

Dr. Hicks lays most stress on the specimens determined as *Stricklandinia lirata*, Sow., of which he has figured four examples, viz., fig. 3, p. 267; and pl. x, figs. 6, 7, and 8. Of the four specimens, that shown on fig. 8 may be left out of account, as it is a smaller and less satisfactory specimen of the form shown in fig. 6, with which it fully agrees; while that drawn on pl. x, fig. 7 has lost the upper part of the shell, so that its family position is indeterminable; the dotted line on the plate which suggests the position of the hinge-line and beak is hypothetical.

The two remaining specimens show three characters—

1. The hinge-line is recognizable in the specimen shown in fig. 3, although it is not seen in the figure; the hinge-line is straighter than in the genus *Stricklandinia*, and agrees rather with *Orthotetes*.

2. The muscular impressions. A pair of scars are shown on pl. x, fig. 6, which Dr. Hicks identifies as muscular impressions. If this be correct, it tells strongly against the fossil being a *Stricklandinia*, for the muscular scars are far too large and wide; they agree with those of *Orthotetes*, especially with those of the subgenus *Hipparionyx*.

3. The shape of the shell. The specimen that offers the most reliable evidence as to the shape of the shell is shown in pl. x, fig. 6. The specimen is much higher than it is broad (ratio 18 : 11); whereas in adult *Stricklandinia lirata*, the ratio of height to breadth varies from 18 : 22 to 18 : 26. The fact that the height of the Morte Slate specimen is twice as great as in *Stricklandinia lirata*, may be explained as due to crushing. But if the height of the shell has been increased and its width decreased by deformation, then the muscular scars also must have their breadth decreased by deformation. They are, however, already far too wide for *Stricklandinia*; so to include the Morte Slate fossil in that genus, we must assume that the crushing of the specimen rolled out the shell in one direction and the muscular impressions at right angles to that direction.

The evidence of the two specimens (fig. 3, and pl. x, fig. 6), therefore, appears to me conclusive that they do not belong to *Stricklandinia*. To what genus, then, do they belong? There is a striking resemblance in form and in the nature of the muscular impressions, as well as a general agreement in size and hinge-line, between these specimens and that figured by Davidson as *Orthis hipparionix* in his "Devonian Brachiopoda," pl. xvii, fig. 8. The specimen shown in that figure belongs to a species which is probably allied to one previously figured by Davidson (loc. cit., pl. v, fig. 8) as *Spirifera disjuncta* var. *gigantea*. Davidson so named that figure from the belief that his specimen was identical with the form named by Sowerby *Spirifera gigantea*. In this Davidson appears to me to have been in error. Sowerby's specimen was a *Spirifera*, whereas the specimen which Davidson confused with it is either an *Orthotetes*

or an *Hipparionyx*. The mistake was unfortunate, for it continued the union of two distinct species under the name *Spirifera disjuncta*, one of which, as Professor Hughes suggested, is the same or a very close ally of the Morte Slate fossil.

The specimen of "*Spirifera disjuncta* var. *gigantea*" came from Tintagel, and that of the *Orthis hipparionix* from Looe. It would be rash to found any argument on the specific relationships between these forms and Dr. Hicks' fossils. But if I had to give the last a name, I should, without much hesitation, call it *Hipparionyx* aff. *proximus*, Vanux, and regard it as also closely allied to *Orthis hipparionyx*, Dav. *non* Hall, and to *Spirifera disjuncta* (*pars*), Dav., var. *gigantea*, Dav. *non* Sow. If I am right, the affinities of the species are decidedly Devonian.

Dr. Hicks is warmly to be congratulated on the success which has attended his persevering and painstaking search for fossils in such unpromising material as the Morte Slates; and every geologist interested in the Devonian question will feel grateful to him for his addition of this interesting fauna to the materials available for the solution of that problem. The determination of crushed casts of fossils is a task which is always difficult, but is often necessary, and fortunately is frequently possible. The truth is generally reached in such cases by a series of suggestions, of which one after another is shown to be incorrect. Accordingly, the publication of this note may help in the final determination of the age of the Morte Slates, even though its conclusion that the affinities of the fauna are Devonian rather than Silurian be proved erroneous.

III.—Note on British Geological Photographs.

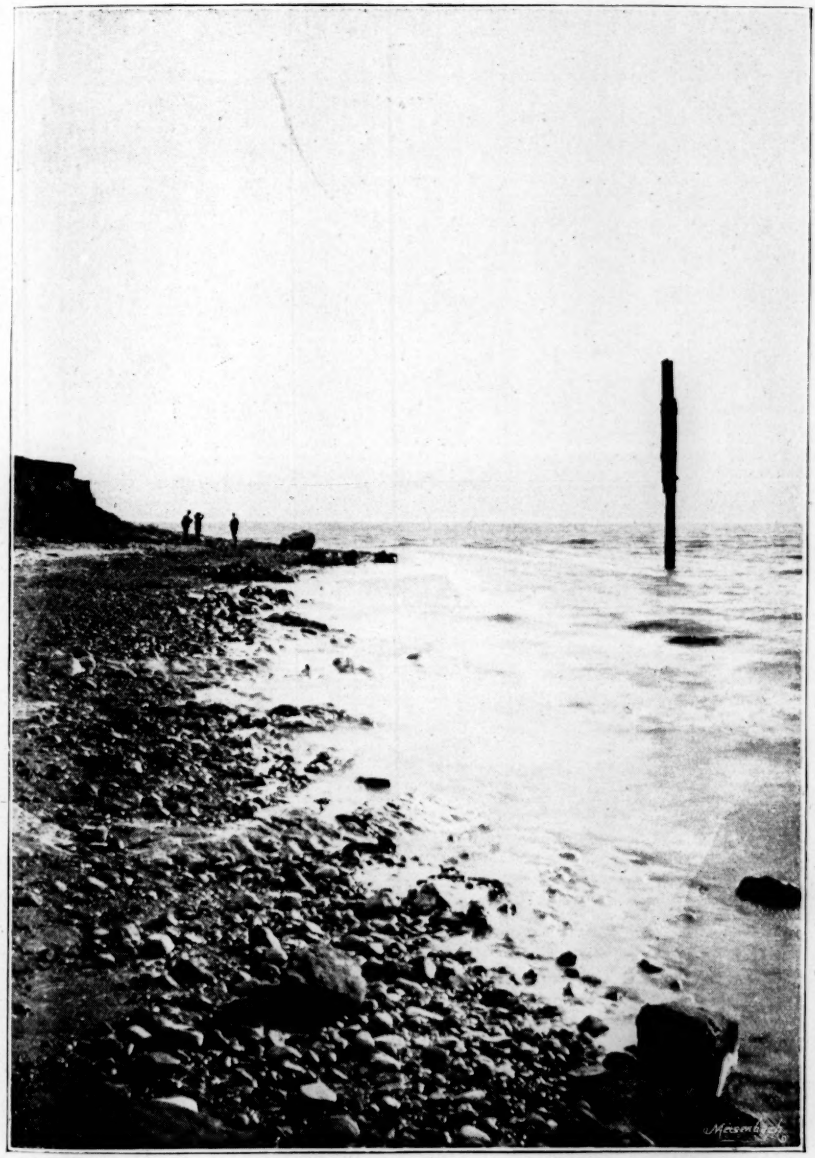
By W. W. Watts, M.A., F.G.S.

(*Continued from the January Number, page* 37.)

(PLATE II.)

In illustration of the article on this subject published in last month's Geological Magazine, three plates have been prepared by the kind permission of the photographers, and of the editors of the publications in which they originally appeared. One (namely Plate II) is now issued, and Plates III and IV will be given in the March number.

Plate II, which has been lent by the publishers of *The Irish Naturalist* for January, 1893 (vol. ii), by kind permission of Messrs. G. H. Carpenter and R. Lloyd Praeger, represents the remains of a windmill pump photographed by Miss M. K. Andrews. This was erected in 1824 or 1825 to remove the water from an old quarry, and in 1829 is known to have been 50 feet from the sea. It was, when the photograph was taken, 50 feet outside high-water mark, and Miss Andrews informs me that it was completely washed away by the great storm in December, 1894, so that the photograph is the only record that we possess of it.



THE OLD PUMP, CULTRA, CO. DOWN.

From a Photograph by Miss M. K. Andrews: see the IRISH NATURALIST, *Vol. II, No.* 1 (1893), *Pl. I.*

IV.—The "Great Submergence" Again: Clava, etc. Part II.

By Dugald Bell, F.G.S.

LAST month I glanced at some of the difficulties attaching to the theory of a "great submergence" during Glacial times, particularly in connection with the deposition of this shelly clay at Clava.

In regard to the alternative theory of transport by land-ice, the following facts may be enumerated as so far in its favour:—

(*a*) Evidences of ice-action are conspicuous all over the district. It is a region of intense glaciation, and this special locality is right in the tract of the ancient ice-sheet.

(*b*) The traces of the movement show that, with a very small submergence, the ice-sheet must have passed over part of a former sea-bottom.

(*c*) That in this neighbourhood it *rose* in its progress, carrying numerous boulders with it in its course, and leaving them at higher elevations than their parent beds of rock.

These facts, we submit, give a *primâ facie* probability to the ice-transport theory—to this extent at least, as showing that it does not assume an agency or condition of things which cannot otherwise be shown to have existed. The agency and conditions it assumes are clearly made out to have been in force in the place and at the time, and to have acted in the direction and on the scale, required.

Has the submergence theory, on the other hand, any such independent evidence to support it? Mr. Smith, for example, assumes "deep, still water" at Clava, implying a total submergence of about 1000 feet; and to this he adds "surface-currents carrying thin shore-ice" laden with mud, stones, shells, etc. What is there to support all these hypotheses? Apart from the difficulty raised by several eminent physicists as to the likelihood of there being any ice at all in this country, with such a submergence, we ask where are there any traces of the assumed shore-line, at 1000 feet above the present sea-level, from which the hypothetical "shore-ice" started? Are there no fragments of it among the hills of the district, or anywhere over the country? Is the whole thing a series of suppositions made to suit this particular case—resting on nothing—hanging, as it were, in the clouds? At this rate, one can imagine anything—even (as has been done) immense changes in the distribution of sea and land, three or four times repeated, to explain some purely local phenomena!

Let us look now at some of Mr. Smith's objections to the theory of the shells, or shelly clay, having been transported by land-ice, merely premising that the many instances in which this theory is undeniably true constitute a probability in favour of its being true in this instance also.

(1) So far as has been observed, there are no striations on the shells; and "it is physically impossible," says Mr. Smith, "that the shelly clay with stones, or even the shells" could have been transported by land-ice without being striated. They might, indeed,

have escaped striation by being carried on the surface of the ice; but "the shelly clay," Mr. Smith kindly informs us, "cannot possibly have fallen on the surface of the ice, neither could it have been carried up *under* it without many of the shells (if not all in this case) having been striated." Therefore it is "physically impossible."

We may remark that men of science are in general rather chary of saying what is "physically impossible," or not impossible, and the most capable are the most chary. It is awkward to pronounce anything "physically impossible," and then find out that somehow or other it has been done!

In the present instance, besides being carried *on* the ice, or pushed along *under* it, may not shells, etc., be taken up into the mass of the ice and encased and imbedded *in it*, and so transported considerable distances uninjured? Mr. Lamplugh, in one of his admirable papers, has said that while he cannot fully explain how the ice has done this, he has no doubt of the fact. He has found the most delicate shells uninjured in the transported clays of the north-east of England; and in the Boulder-clay of British Columbia he discovered shells actually more perfect than those he could pick up on the existing beach. In the same way Mr. Mellard Reade has noticed the occurrence of long thin slabs of chalk in the Boulder-clay of Cromer, and marvelled how they could have been transported entire or without being shattered to pieces.[1] And Dr. James Geikie has remarked that boulders once imbedded in the ice may be carried for "a hundred miles without suffering abrasion."[2]

Thinking the matter over, it has occurred to the present writer that wherever the ice-sheet passes from a deeper to a shallower part of its bed it has probably a tendency to insinuate itself beneath anything resting on the slope up which it is moving, and lift or *lick up* such things (as stones, shells, masses of shelly clay) into itself, and so carry them forward and upward with it. Thus the Loch Lomond ice, passing from the deep part of that loch to the shallower part, caught up numerous marine shells (the relics of a preceding *moderate* submergence) and deposited them with the till in the neighbourhood of Drymen. The Moray Firth ice, passing on to the mainland of Caithness; the Irish Sea ice, impinging on Moel Tryfaen, and the Loch Ness ice in its course towards Clava, seem all to be instances of the same kind.

But whether this suggestion be accepted or not does not alter the fact. If Mr. Smith asserts that it is "physically impossible" we

[1] Q.J.G.S., vol. xxxviii.

[2] "Great Ice Age," 3rd edition, p. 204.—A good example of how materials may be conveyed with very little injury when imbedded in the ice (in whatever way they got there) is furnished by the well-known sad incident of Dr. Hamel's three guides, who lost their lives by being swept by an avalanche into the *berg-schrund* of the Glacier des Bossons, Mont Blanc, in 1820. In 1861 the glacier, near its lower extremity, gave back the remains of what it had swallowed up forty-one years before. "Scientific instruments, knapsacks, gloves, etc., were gradually set free from their icy fetters. A *gauze veil* came out untorn and not much faded; and the knapsack of Pierre Carrier contained a *leg of mutton* perfectly recognisable!" (See "Le Mont Blanc," by C. Durier, and Main's "My Home in the Alps," p. 68.)

would ask him to say how he knows. If by observation, where and how were the observations conducted? if by testimony, who are his authors? if by intuition, there we must leave him.

(2) Mr. Smith states that if the shelly clay had been deposited by the ice in an extra-glacial lake (as the present writer supposed) "it ought to have contained abundance of vegetable matter, fresh-water mollusca, fresh-water diatoms, fresh-water Ostracoda, etc." In reply to this it was pointed out, when Mr. Smith read his paper to the Glasgow Society, that such glacial lakes are notable for the absence of organisms of any kind, for the azoic character of their sediments. Such instances were referred to as the Merjelen See in Switzerland, the beaches of the old glacial lakes in Glen Roy (which, because they do not contain fresh-water organisms, some argue must be marine, not seeing that there is a greater difficulty on that side in the total absence of marine organisms), and the mud or clay deposits of the old glacial "Lake Humber," traced out in England by the late Professor Carvill Lewis, which, he remarks, is "entirely devoid of traces of animal life, and the only bodies of water known to be so are lakes bordering on glaciers."[1]

These facts, we say, were pressed upon Mr. Smith's attention when his paper was read. Are they not relevant, or of importance as bearing on the point in hand? Why, then, does he not meet and answer them, instead of simply passing them by and repeating his original assertion, which they disprove? Does he imagine he can carry his case by sheer reiteration? Apparently![2]

(3) In some respects, it must be admitted, Mr. Smith's "interpretation" of the section is original. He deals largely in hypothetical "currents," and manipulates them as "surface" or "bottom" currents according to his requirements. Thus we are told: "The Clava shelly clay says—'*I am a mud; there were no currents flowing where I was laid down.*' . . . It is a deep-water deposit formed in the sea where there were no *bottom* currents. . . . It was formed in deep water by *surface* currents." On the other hand, the bed of fine sand overlying it, 20 feet in thickness, was "formed by *bottom* currents." (GEOL. MAG., November, 1896, pp. 500–2.) Mr. Smith reads it all off as easily as Dr. Hornbook rattled over the Latin names of his medicines—"like A B C." But let us consider. How do we get these surface and bottom currents so conveniently? Between these two members of the series—the fine clay and the overlying sand—was the land "hitched up" some 700 or 800 feet, so that what was

[1] H. Carvill Lewis, "Glacial Geology of Great Britain," p. 58.

[2] Another matter of complaint which we have against Mr. Smith is in regard to a foolish trick he has of *exaggeration*. Thus he says: "In the Clava case the marine material would require to have travelled *over* '*hill and dale*' some ten miles." (See GEOL. MAG., November, 1896, p. 500.) Now, in previous papers it was pointed out that the slope from the level of Loch Ness to Clava is exceedingly gentle; that this is a feature which strikes one from various points of view in the neighbourhood; and that a rise of 500 feet in ten miles, or one in a hundred, is so small as to be practically imperceptible. Those statements no doubt Mr. Smith has read, and he makes a show of having "regard to facts." Why, then, does he lay on with the *big brush* "over hill and dale"?

a "surface current" in the one case became a "bottom current" in the other? And was this a *sudden* catastrophe? With what immense displacements of water, huge "waves of translation," etc., it must have been accompanied! How did the fine clay (which says "*I am a mud*") escape in such a turmoil? Or was it—as seems on the whole more likely—a *gradual* operation, extending, perhaps, over tens of thousands of years? (We are arguing on the supposition that there was such a submergence and re-elevation, which we do not believe.) Then will Mr. Smith please to remark that in the gradual re-elevation of the land, all his "deep-sea deposits" would successively be placed in the condition of shallow-water and shore deposits again. And if, in his own words, "the shore waves constantly agitate the material they come in contact with, washing out the mud and forming gravels and sands" (p. 501), then what chance had his fine clay (which says "*I am a mud*") of being preserved—exposed, as it must have been for an indefinitely long period, to the shore waves of the Northern Sea and to the powerful currents that swept to and fro through the Great Glen? We can, indeed, hardly imagine a more unlikely place than Clava for the existence of "still water" at any time, or for such deposits as these fine clays and sands being preserved.

(4) Touching, in conclusion, on another subject, Mr. Smith thinks "there is ample proof that they [the Boulder-clays of Ayrshire] are marine deposits." From his examination of them he says he is "finding additional proofs of the *whole drift formation* having been deposited in the sea." We have already expressed a *caveat* against rushing to conclusions in that matter (GEOL. MAG., July, 1896), which, though it has not been much attended to as yet, we hereby beg to repeat. The shells, of which "the great bulk occur as fragments, although there are some very good specimens," are found in the usual Boulder-clay (or clays) of the district, and in certain associated sands and gravels, evidently "washes" therefrom. These boulder-clays are of the ordinary massive, unstratified kind, showing, it is true, here and there traces of bedding, with thin layers of sand and gravel, as in all other boulder-clays, but no regular and continuous stratification. They take their colour and composition chiefly from the immediately underlying or adjacent strata; but they contain, mingled with the rocks of the district, a considerable proportion of far-travelled blocks from the Highland mountains to the north-west *on the opposite side of the Firth*. These characteristics, we submit, mark them as undoubted glacial deposits, which cannot be accounted for by the action of shore-ice (thick or thin), pack-ice, icebergs, or floating ice of any kind. Besides, all floating ice requires currents; and our powers fail us in trying to conceive of a set of marine currents diverging from the West Highland mountains—westward to the Sounds of Lorne and Jura; eastward by the central valley to the Firth of Forth; and south-south-eastward, across the Firth of Clyde to the bays and recesses of the hills in Ayrshire.

⁂ In an article by Mr. Mellard Reade on the "Present Aspects of Glacial Geology," which appeared in the December number of this Magazine, there is the following note:—

"Mr. Dugald Bell, previous to the discoveries of Mr. Smith in Ayrshire, threw such doubts upon the recorded instances of the occurrence of shells in the Drift of the South of Scotland that the stock example of Chapelhall, near Airdrie, which was supposed to prove a submergence of about 500 feet, was omitted in the last edition of Dr. James Geikie's well-known 'Ice Age.' A committee with Mr. Dugald Bell as a member re-examined the locality, with a result entirely *negative*. This is only another instance of the futility of *negative* evidence, for, as we see, not long afterwards evidence of the most conclusive sort of the presence of sea-shells in natural sections open to the world were found in Ayrshire up to double the height." (GEOL. MAG., December, 1896, p. 549.)

There are several points here.

1. The doubts expressed regarding Chapelhall—referring to the narrowness of the basis of evidence on which it rested, and the probability of the clay not being *in situ*—belonged to that case in itself, and are wholly unaffected by anything discovered elsewhere, whether before or since. The same doubts should be expressed in the same terms still, were the case still to open.

2. It was not the expression of these doubts, however well founded they might appear to him, which induced Professor Geikie to suppress this "stock instance" in the last edition of his work; it was the corroboration or substantiation of them by the Committee of the British Association failing to find the clay in the position indicated by all the accounts of it, or in the neighbourhood. Dr. Geikie then justly suppressed it, as unsupported by evidence; the only fault that can be found with him being that he did not state any reason for doing so.

3. Though in one sense the result of the Committee's investigation was *negative*, in so far that the clay was not found, in another it was quite *positive*: the clay was not where it was reported to be. It was said to be in the excavation for a certain well, 14 ft. from the surface, as a bed 19 ft. long by 5 ft. broad, and 2 ft. thick in the centre. The Report of the Committee showed that no such bed of clay could have escaped their search, and that in other respects the statements so long repeated did not tally with the facts (see British Association Reports, 1894). It was evident that "some one had blundered," or had been misled. Why this result should be called "futile" because something else—a boulder-clay at the same or a greater elevation—has been discovered elsewhere, I cannot imagine. Every case must be decided on its own evidence. Chapelhall has collapsed. The value of the Ayrshire sections as proofs of submergence has yet to be determined. My own opinion, frankly, is that it is *nil*; but I keep my mind open till the evidence be more fully wrought out, and meantime deprecate hasty and sweeping statements on the subject.

4. In another part of his paper Mr. Mellard Reade speaks of "a great glacier proceeding from the Atlantic, crossing Kintyre and the Firth of Clyde, and working 25 miles inland" into Ayrshire, as if that were the idea involved in the theory of those

who do not accept submergence. We are sorry our friend should have indulged in such a fantastic supposition. Is not the bed of the Firth of Clyde itself large enough to supply any marine remains that may be in question? Why go out to the Atlantic for them? The truth is, the whole evidence goes to show that such was the congested and over-brimming condition of the Firth of Clyde as one of the main outlets for the land-ice of the country—the ice of the West Highland, Ayrshire, and Galloway mountains, augmented by that of Arran in the Firth itself—that a large section of the frozen stream was deflected *westward across Kintyre* (exactly in the opposite direction figured by Mr. Reade), and so *out* to the Atlantic in that direction (see Brit. Assoc. Report, Kintyre Shelly Clays, 1896). Finally, when the ice in the Firth of Clyde was of such dimensions that it passed straight on over Bute, the Cumbraes, and Ailsa Crag, where do we suppose its outer edge lay in Ayrshire, or along the Ayrshire coast? Can we fix a nearer point for it than along the flanks of the hills which divide Ayrshire from Renfrewshire and Lanarkshire, where fragments of West Highland rocks are numerous, and these patches of high-level shelly boulder-clay are chiefly found?

V.—The Oldest *Siphonotreta*.

By G. F. Matthew, D.Sc., F.R.S.C.

(Read before the Natural History Society of New Brunswick, January 5, 1897.)

THE ancient Brachiopodous genus *Siphonotreta* is well known by its species occurring in the Ordovician and Silurian strata of Russia and Great Britain, and its peculiar pedicle opening has been the subject of remark. The author is not aware that this genus has hitherto been reported from any Cambrian terrain, and, therefore, the greatest interest will attach to a form recently found in the lower beds of the St. John Group, which is nearer to *Siphonotreta* than to any other known genus.

The new form is remarkable, so far as its pedicle passage is concerned, in combining the two genera *Siphonotreta* and *Schizambon*; for in its early stages it had the dorsal furrow of the latter genus, but afterwards it developed the tubular passage seen in the former.

This shell is older than any *Paradoxides*, being of the *Protolenus* Fauna,[1] and is found in strata that nearly correspond in age to the beds which at another locality carry the related genus *Trematobolus*. But while the new form abandoned the Schizambonal opening for its pedicle, and adopted a contracted canal for the passage of this organ similar to that of *Siphonotreta, Trematobolus* maintained the open fissure (or hole) through life.

Young individuals of the new form of the size of *Schizambon typicalis*, Walcott, are actual examples of the genus *Schizambon*. The history of the growth of the species from the larval forms to maturity is shown by exfoliated shells, in which the siphon stands

[1] Trans. New York Acad. Sci., vol. xiv, pp. 101–153.

out, while the adjoining shell-layers are weathered away. The shell of this species was thin during the Schizambonal stage, but thickened rapidly by the accretion of layers within the shell during the Siphonotretal stage. As, however, the parts of these layers around the tube were not perfectly calcified, that organ in exfoliated shells stands out and remains as a projecting tube, after the layers of shell, as above remarked, are weathered away.

In an exfoliated shell, therefore, we have a siphon projecting from what seems to be the inner side of the shell, and simulating the figures given of the interior of the ventral valve of *Siphonotreta unguiculata*, Eichwald.[1] And the resemblance to that species in other respects is significant, for, in the first place, the passage for the pedicle in the new form diminishes in size from that which it had at the close of the Schizambonal stage, until maturity; and it will be noted that in the species of *Siphonotreta* named above, it is said that the internal tube diminishes in size as it passes inward.[2]

It is also stated that in *Siphonotreta unguiculata* the muscle-marks are very near the internal opening of the tube. This is not noticeably the case with the new form when the interior of the shell is completely preserved; but in exfoliated examples where the siphonal tube is exposed, the muscle-markings on the shell-layers remaining, being those of the early Siphonotretal condition, are much nearer the siphon, and so are like those accredited to the species above named.

The new form has no exsert siphon showing on the inner surface of the shell, and it will easily be seen that such a projecting tube would involve anatomical conditions different from those of most of the early Neotrematous Brachiopoda. It would appear that a siphon projecting inside the shell is not an invariable characteristic of *Siphonotreta*, for Davidson figures *S. unguiculata* with a scarcely projecting siphon,[3] and De Verneuil shows the inside of an umbo of *S. verrucosa*, De V., in which the opening for the pedicle lies in a little saucer-shaped hollow, as in our species.[4]

In some species referred to *Siphonotreta*, the pedicle passage opens outward just behind the beak; in others a channel extends along the back of the shell for some distance, and then a hole gives passage to the interior of the shell, there being no siphon or tube. These latter have been divided off by Walcott as the genus *Schizambon*. Since, however, the St. John species agrees exactly neither with this section nor the other, but in its pedicle passage combines the characters of both, it is necessary to establish for it a separate place. Linking together as it does the genera of De Verneuil and Walcott, it would seem proper to regard both *Schizambon* and the new form as subgenera of *Siphonotreta*, and with this view the author would propose for the new form the name PROTOSIPHON, for which the above remarks will give the essential characters.

[1] See "Manual of the Mollusca," S. P. Woodward, London, 1875, p. 390, fig. 201.

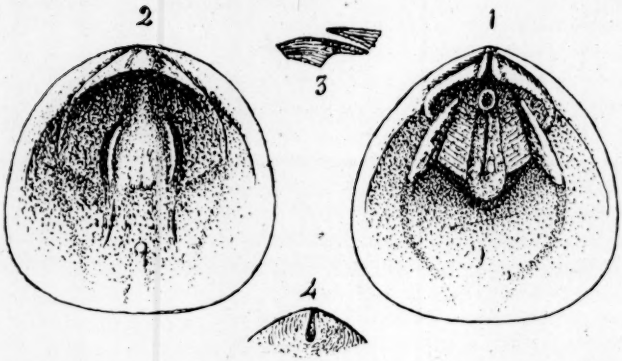
[2] Hall and Clarke, "Genera of Palæozoic Brachiopoda," Albany, 1892, p. 110.

[3] GEOL. MAG., London, 1877, Pl. II, Figs. 9, 11. See also Hall and Clarke, "Genera of Palæozoic Brachiopoda," pl. iv, fig. 25.

[4] "Russia and the Ural Mountains," Paris, 1845, vol. ii, pl. i, fig. 14*d*.

PROTOSIPHON, n. subgen.

PROTOSIPHON KEMPANUM, n.sp.[1]



Protosiphon Kempanum.—1. Interior of the ventral valve, showing scars of central and lateral muscles, opening of the siphon, vascular trunks, etc. 2. Interior of the dorsal valve, showing position of the central and lateral muscles, median ridge, vascular trunks, etc. 3. Section of the beak of the ventral valve, showing the passage for the pedicle. 4. Umbo of the ventral valve viewed from above, showing the Schizambonal furrow.—All the figures are magnified $\frac{2}{1}$, except No. 3, which is enlarged $\frac{4}{1}$.—N.B. The large figures are somewhat idealized, as some features (e.g. the vascular trunks) are supplied from examples other than the two which formed the basis of these drawings.

Shell substance calcareo-corneous. Outline of the dorsal valve somewhat oblately orbicular; outline of the ventral valve similar, but with an obtusely pointed beak. Both valves moderately convex, and marked at the hinge area by transverse ridges of growth. The ventral valve has a depressed channel on the back, beginning at the beak and ending forward in a tube buried in the substance of the shell, and terminating inwardly in the visceral cavity by a minute opening.

The dorsal valve does not differ much from the ventral, except in the absence of a projecting beak, and in being more tumid in the posterior half. Both valves have a broad, shallow sinus towards the front, and so are there straighter than in other parts of their circumference.

The edges of both valves are flattened on the underside, and thickened at the cardinal line, where they are traversed by arched ridges and furrows, which may serve the purpose of articulation. A depression similar to a pedicle groove traverses the cardinal area of the ventral valve on the axial line; and a low tubercle holds a similar position on the dorsal valve.

Sculpture.—The surface of the shell is marked by fine lines, concentric to the umbo, and at intervals by stronger growth-lines.

[1] Dedicated to Dr. J. F. Kemp, Professor of Geology at Columbia College University, New York, well known for his work on the Archæan and Cambrian Geology of the State of New York.

Interrupted rows of tubercles appear in certain places along these lines of growth.

Size.—The largest dorsal observed was 19 mm. long and 20 mm. wide. A ventral valve of corresponding size would be 1 mm. longer. Height of each valve about 5 mm.

Horizon and Locality.—In the olive-grey sandstones of Division 1*b* of the St. John Group at Long Island in Kennebecasis Bay, King's County, N. B. Canada. The exact horizon in Band *b* is uncertain: there are about fifty feet in thickness of these sandstones exposed, and they have the aspect of Assises 2 to 4; being from the upper part of the sandstones the species is probably from Assise 3 or Assise 4. These shells are found sparsely distributed in sporadic, lenticular layers, having the valves promiscuously packed within each other, as though after death they had been somewhat rolled on a beach, or in a shallow sea.

Further particulars of this species will be given in an article in preparation for the Royal Society of Canada.

St. John, N. B. Canada.

REVIEWS.

I.—Dr. Croll's Life and Work. By James Campbell Irons, M.A. pp. 553, including Index and two Portraits. (E. Stanford, 1896. Price 12*s*.)

SIX years have elapsed since the death of Dr. Croll, and we are now presented with a Memoir of his Life and Work from the pen of his Edinburgh friend, Mr. J. C. Irons, assisted in some degree by his brother, the Rev. David E. Irons, of Glasgow. We quite agree with the author that the life of such a man, "recording the triumph over his early struggles, his scientific researches, which secured him a worldwide reputation as an original thinker, and his earnest belief in the Christian faith," should prove interesting. There is something fascinating in Croll's biography. His was an eminently Scottish type of character, and it may be safely asserted that no other country than North Britain could have produced such a marked individuality.

His autobiographical sketch (pp. 9–41), constituting a sort of introduction to the present volume, should be read carefully in order to understand the man. We thus realize, from the perusal of a few clearly-written pages, his struggles with poverty and ill-health, his thirst for knowledge, his natural inclination towards metaphysics, his ultimate absorption in physical speculations, his fortunate appointment as doorkeeper at the Andersonian Museum in Glasgow, and, lastly, his acceptance of employment on the Geological Survey of Scotland. It is only right to add that he tells us of his general indifference, in the outset of his career, for sciences involving so much detail as geology and chemistry. As regards the former, he observes (p. 14) that it is the only science on which (with

the exception of glacial phenomena) he never spent a single day's earnest study.

It is not our purpose to offer any criticisms in the GEOLOGICAL MAGAZINE on the volume by Mr. Campbell Irons now before us, although a short synopsis of its contents may not be altogether out of place.

The early days of the Perthshire youth are duly recorded; and from this we pass to notices of his literary and early scientific work. As regards the latter, our author observes (p. 97) that "for many years he [Croll] devoted his attention chiefly to the great problems of theoretic geology, and in 1864 he began the brilliant series of solutions which make his name illustrious in the history of this science." An account of the early physical papers, 1861–4, is given, and we learn that, about the latter date, Dr. Croll received the congratulations of the late Sir Andrew Ramsay on his work. He was now fairly launched in his career of scientific speculation, and, as a consequence, entered into correspondence with Ramsay, Lyell, Herschel, Hooker, Charles Darwin, and other eminent men, both geologists and physicists. A very considerable portion of the volume is devoted to this correspondence in connection with the several subjects taken up by Dr. Croll, all of which bore more or less on the questions discussed in "Climate and Time," first published in 1875. In the following year he was elected a Fellow of the Royal Society.

This intermingling of personal history with scientific correspondence is continued down to the period when Dr. Croll found it necessary, in 1881, to resign his appointment on the Geological Survey of Scotland owing to ill-health, after having served for thirteen years. The scientific correspondence is still maintained, and the letters he received with reference to "Climate and Time," "Climate and Cosmology," etc., are often very suggestive. Amongst other things Dr. Croll tried his hand at "Stellar Evolution," a pursuit which involved him in correspondence with Winchell, G. H. Darwin, Alfred R. Wallace, and other distinguished scientists. In 1889 he received a letter of thanks from Dr. Nansen, to whom he had sent copies of some of his works.

The concluding chapters relate to the "Closing days" of Dr. Croll's career, when he returned to speculations more or less metaphysical. The "Philosophical Basis of Evolution" was his last work, and this he was just able to see in print before he died. Mr. Irons also reproduces obituary notices—by Lord Kelvin as President of the Royal Society, by a writer in *Nature*, and by Mr. J. Horne, of the Geological Survey of Scotland, all of which do justice to Dr. Croll's character and attainments.

A considerable portion of Croll's work made its first appearance in the *Philosophical Magazine* and in the *Reader*, but he also contributed several articles and letters to the GEOLOGICAL MAGAZINE, more especially in the years immediately preceding the publication of "Climate and Time." The substance of these articles was for

the most part embodied in that work, more especially one "On the Path of the Ice-sheet in North-Western Europe and its Relations to the Boulder-clay of Caithness." In the GEOLOGICAL MAGAZINE for September, 1878, he wrote an article criticizing "Cataclysmic Theories of Geological Climate," and there have been a few short communications of a subsequent date.

Very different estimates have been formed from time to time of the value of Croll's speculations, though none can doubt that they offer problems of a deeply interesting nature. We may almost regard "Climate and Time" as a poem; though its author was perhaps somewhat too controversial in his nature to be regarded as a genuine *vates*. It is not for us, as geologists, to question the accuracy of the calculations whereby the eccentricity of the Earth's orbit has been estimated throughout three million years of past time and one million years of future time. Leverrier, it seems, was content to give a table of the eccentricity for 100,000 years before and after A.D. 1800. This was thought sufficient for ordinary astronomical purposes, but is clearly too limited for geological epochs. The most curious feature in this connection is the statement by Croll's biographer (p. 491) that "the keenness and directness of his marvellous logical faculty is by no means least clearly demonstrated in his marvellous calculations of millions of years and intricate mathematical problems, which, as he knew little of mathematics, he worked out by a process of figure-logic entirely his own." We also learn incidentally from a statement made by Lord Kelvin (p. 500) that Croll was not at all times very sound in arithmetic. Nevertheless, the same authority observes that his "Essay on the Physical Cause of the Changes of Climate during the Glacial Epoch" deservedly gained the careful consideration both of geologists and of astronomers.

Although some may be disposed to question the value of Croll's calculations, there can be little doubt that many of his arguments on terrestrial physics carry considerable weight with them. There is a certain fascination about his theory of the alternate glaciation of the hemispheres; whilst it is indisputable that at the present time, notwithstanding the low value of the eccentricity, the hemisphere whose winter is in aphelion is much the colder, as required by his hypothesis. How far Lyell's explanation of this fact is to be relied upon it is difficult to say; but one apparent cause, as pointed out by Croll, may be sought in the northerly deflection of the equatorial currents, whereby a portion of the warmth which should belong to the southern hemisphere is transferred to the northern. But what is the agency which brings this about? According to Croll, it is the excess of southern cold producing a preponderance of the south-east trade-winds. We are thus forced to fall back on the *primary* cause of this excess of cold, which Croll no doubt would attribute to the fact of the southern winter occurring in aphelion. Other physicists there are who contest this conclusion. A better acquaintance with the Antarctic regions than we at present possess might be of service at this stage of the inquiry.

Whether right or wrong, the Astronomical Theory of Geological Climate, which found in Croll its most original advocate, has met with no small degree of acceptance in the world of science. Thus, under the article "Geology" in the *Encyclopædia Britannica*, Croll contributed an outline of the "Secular Theory of the Change of Geological Climate"; whilst a full abstract of his views on Climate in its Geological relations, drawn up by himself, was admitted into Sir Archibald Geikie's "Textbook of Geology" (1882, p. 23 et seq.). More recently somewhat similar views have been expressed by Sir Robert Ball in his "Cause of an Ice Age," which appeared in 1891, and has since been published in the "Modern Science" Series, thus indicating by implication the general acceptance of the theory, now no longer regarded as a mere hypothesis.

Nevertheless, from time to time, critics have arisen who ventured, in a greater or less degree, to contest the methods by which these conclusions have been reached. It will suffice to instance two from our own pages. The Rev. E. Hill, in an article on "Eccentricity and Glacial Epochs" (GEOLOGICAL MAGAZINE, February, 1880), prefaces his criticisms by the admission that "Climate and Time" was perhaps the most important geological work that had recently appeared; "certainly," he says, "the most valuable and original that refers to Glacial Geology. It teems with novel and instructive ideas." Then comes the criticism, summed up as follows:—"We have thus gone through Dr. Croll's four causes, or rather modes of action, whereby high eccentricity might, as he maintains, produce a Glacial period. The first is non-existent. The second may possibly have an effect. The third at best cannot work at all, and almost certainly works in the wrong direction. The fourth [deflection of ocean currents owing to intenser trade-winds] might work if set agoing, but has no power of starting itself?" Mr. Hill's verdict, therefore, was one of "Not Proven," though he considered that Croll had attacked the problem in a right manner; and he seemed inclined to believe, with Croll, that variations in eccentricity did bring about the Glacial period.

More recently the Astronomical Theory of the Ice Age, as enunciated by Croll, and subsequently (1891) by Sir Robert Ball, has been criticized by Mr. E. P. Culverwell, Fellow of Trinity College, Dublin, in the GEOLOGICAL MAGAZINE (January and February, 1895). This author considered himself justified in stating "that a careful examination of the problem will show that the theory is but a vague speculation; clothed, indeed, with a delusive semblance of severe numerical accuracy, but having no foundation in physical fact, and built up of parts which do not dovetail one into the other." It is for mathematicians and physicists to decide between these contending authorities. But we may, at least, call attention to Seebohm's description of the advent of summer in Siberia, as quoted by Mr. Culverwell; who complains that Croll's illustrations of the effect of summer heat are all selected from regions where the sun-heat has to contend, not only with the ice or snow actually on the ground, but also with the cold

drift-currents bearing great masses of ice and snow from the Polar regions.

Apart from all considerations involving abstruse mathematical demonstration, there is one important section of Croll's speculations which must commend itself to those who are desirous of investigating the subject of Climates, past and present. He insisted upon the importance of the warm-water apparatus of the globe in modifying these. We may even believe with him that the "real and effective cause of the disappearance of the ice [of the Glacial epoch] was the enormous transference of heat to temperate and polar regions by means of equatorial currents" (GEOLOGICAL MAGAZINE, 1879, p. 480). True, it is difficult to understand in view of his theory that the colder hemisphere forces the equatorial currents away from itself, how this could be, unless some other and more powerful cause operated to counteract the above-mentioned tendency. This, however, merely refers to causes directing the equatorial currents, and does not affect the general question of their influence.

The general oceanic circulation is, of course, modified by latitude and certain local causes, and this is especially noticeable in the North Atlantic; where the steady set of warm surface water towards the north-east, partly initiated by the Florida current, helps to produce such a remarkable contrast between the climate of western Europe and that of corresponding latitudes in eastern America. This difference is evidently one of some antiquity, since the causes whice produce it now were evidently in operation in the Glacial epoch. For the glaciation in eastern America, as was thoroughly realized by Croll, extended some ten degrees further south than it did in western Europe. This fact should be borne in mind by persons who are desirous of attributing the cold of the Glacial epoch to interference with the Gulf Stream, since some of the effects for which that agency is held accountable were certainly produced during the period of Pleistocene glaciation.

Lastly, we must consider Croll as a geologist, or rather as a glacialist, for he expressly repudiates any knowledge of geology otherwise than in connection with Boulder-clay. In this department he may be said to have done some really practical work by helping to demonstrate the occurrence of important physical features, such as pre-Glacial river-channels, etc. Indeed, his acquaintance with Boulder-clay areas in the Scottish Midlands seems to have been one of his strong points, and he was able to draw important inferences from the knowledge thus obtained.

Although much that belongs to the history of the Glacial epoch remains as mere hypothesis even to the present day, we owe to the school of which Croll was an eminent member the recognition of the fact that the phenomena of the Boulder-clay and its accessories are in the main due to the action of land-ice. After Jamieson's brilliant explanation of the origin of the parallel roads of Glenroy, the land-ice, or glacier theory, has passed from the region of hypothesis to that of demonstration, and should form the basis of all reasoning

on the subject. It follows, therefore, that the valleys of Scotland and the north of England must at one time have been gorged with ice, and thus many of Croll's postulates are undoubtedly true. But his was a vivid imagination, and the *perfervidum ingenium* of his race transported him, possibly beyond the bounds of probability, in the tremendous expansion which he gave to the glaciation of these islands generally. Moreover, there is reason for supposing that, even subsequently to the publication of "Climate and Time," he was a believer in a general Arctic ice-cap (see GEOLOGICAL MAGAZINE, 1878, p. 396); whereas it is pretty clear, from the experiences of Nordenskiöld and other eminent scientific travellers, that glaciation, as developed in the northern hemisphere, is a local phenomenon dependent on the existence of mountain ranges, or at least of elevated tracts of land. In the Arctic Ocean itself such an island as Kolguev, for instance, has received its glacial débris from the high lands to the southwards, and not in any sense from the direction of the North Pole.

In other respects also Croll's geological ideas were of an eminently speculative character. He marshals an imposing array of figures, as usual, to account for the Great Submergence, which many students of glacial phenomena in these islands regard with considerable doubt, beyond the moderate depression which is indicated by the raised shell-beaches. Indeed, the more advanced glacialists of the present day rather affect to look down upon a "submerger"; whilst some express strong doubts as to the occurrence of Interglacial periods.

But the most awkward circumstance in the geological aspect of Croll's astronomical theory remains yet to be stated. If that theory is sound, there must have been, throughout the Earth's history, a constant recurrence of Glacial epochs. Admitting that considerable climatic changes have been effected, from time to time, by the deflection of ocean currents and the uprise of mountain ranges, is there any evidence, geologically speaking, of the regular recurrence of Glacial periods, as required by the astronomical hypothesis? The geological record is so meagre on this score that Croll felt it necessary to dwell with considerable emphasis on the "misconceptions regarding the evidence of former Glacial periods," arguing that the traces of glaciation are principally to be found on land-surfaces, and that the transference of a land-surface into a sea-bottom would probably obliterate every trace of glaciation. We know that Croll believed in two great epochs of glaciation in Tertiary times, the one in the Eocene and the other in the Miocene period. These he supposed to correspond to certain periods of excessive excentricity, as indicated in his famous diagram. The evidence is confined to regions within the range of Alpine influences, and is perhaps of about as much value in proving the existence of a "Glacial epoch" as the occurrence of a few granite boulders in the Chalk.

The most certain evidences of glaciation previous to the Pleistocene Ice Age are to be found in the southern hemisphere, although even these proofs do not of necessity imply a "Glacial epoch."

The splendid photographs of the famous glacial conglomerate of Wild Duck Creek, brought out by Mr. Dunn in 1892, are probably familiar to some of our readers. The striated bed-rock, believed to be of Silurian age, is most strikingly shown. The subject has been recently brought before the Geological Society by Professor Edgeworth David (February, 1896), who called attention to the "Evidences of Glacial Action in Australia in Permo-Carboniferous Times." It is of course obvious that, if a mountain range attained a certain elevation, it must have been glaciated; but this was more than a mere local phenomenon, and undoubtedly suggests questions of immense interest in relation to the history of the Earth's crust. Quite recently Mr. Strahan has brought to the notice of the Geological Society of London what he regards as Glacial phenomena of Palæozoic age in the Varanger Fjord.

Conceding its full weight to the evidence of some glaciation in Australia, and possibly in South Africa, and even India, in Permo-Carboniferous times, it must be admitted that the geological record is by no means conclusive as to the frequent occurrence of Glacial epochs. On the whole it may be said that, whilst cosmogonists and speculative physicists are perfectly ready to accept evidences of glaciation, and even of several Glacial epochs, throughout the ages, yet geologists, with few exceptions, have failed to draw those inferences which the astronomical hypothesis requires.

It may interest those who are intending to purchase a copy of this work, that the profits of the sale of the book are to be handed to the widow of Dr. Croll, who has been left in somewhat straitened circumstances.

II.—Prehistoric Man and Beast. By the Rev. H. N. Hutchinson, B.A., F.G.S. With Illustrations. 8vo; pp. xxiii, 298. (London, 1896: Smith, Elder & Co. Price 10*s.* 6*d.*)

THE author, an old Rugbeian, who learned his first lessons in Geology under that able and enthusiastic teacher the Ven. J. M. Wilson (now Archdeacon of Manchester), makes his third public appearance in the volume before us. His previous works, "Extinct Monsters" and "Creatures of Other Days," have made his name known as a successful popular writer, more especially as they inspired the clever "Prehistoric Peeps" which were contributed to *Punch* by Mr. E. T. Reed. Unfortunately, this artist in his later sketches has allowed his imagination to run riot with the subject, and to mar the scientific humour of his work.

"Prehistoric Man and Beast" is a book which aims to give, in a simple style, some of the most interesting results arrived at of late years on the antiquity of Man and of the animals associated with him. Such an undertaking is no light one. Above all, a sound judgment must be combined with the knowledge acquired by extensive reading, and with clearness and facility of expression. Only with respect to the first of these qualifications do we find occasional fault with the author, though we can well believe that innocence rather than intention has in certain instances warped

his judgment. This is not surprising when we read in the Preface by Sir Henry Howorth: "My only hesitation in speaking of the book in suitable terms is the exaggerated language which he has been good enough to use about some of my own scattered and desultory gleanings in this field." Nor is it surprising when we read in the author's Preface: "Sir Henry H. Howorth has taken an interest in this work from the beginning, and most kindly read all the proofs, making at the same time valuable notes and comments, which the writer was not slow to use. He has also written a far too flattering Preface, which, coming from so learned an author and so kind a friend, deserves the writer's warmest thanks." After this we are quite prepared for an exposition with approval of some of Sir Henry's peculiar views: and in this respect we are not disappointed.

In his Introduction the author remarks that he makes no attempt to deal with modern speculations regarding the origin of Man from a lower type: "Suffice it to say that he bears in his body the signs of his lowly origin; and that nearly all thinking people of the present day fail to see anything in such a belief contrary to true theology, or to consider that there is anything degrading in the idea." This view may, at any rate, be commended for its boldness.

That the germs of many modern views may be discerned in the writings of the ancients, is to a certain extent true enough; and it is interesting to be reminded that in the days of Job ("if ever such a person lived"), there were observers of geological phenomena. Another writer, indeed, has remarked that to Job probably we owe the hint of the Atlantic Cable, for he was asked—"Canst thou send lightnings, that they may go, and say unto thee, Here we are?" Be this as it may, a reference to the opinion of the wise men of old, whether historians, naturalists, or philosophers, is instructive, and no one need be surprised to be told that "the account of the Creation in the opening chapters of Genesis *implies* evolution."

Starting from the evolutionist's standpoint, the author devotes his first chapter to a consideration of "Our Early Ancestors." He gives an account of the discoveries of Palæolithic implements, and of supposed remains of Palæolithic Man, treating the subject in a very fair and judicious spirit. He hesitates to accept the higher antiquity assigned to the plateau implements of Kent, and he is quite disposed to accept the human remains found at Galley Hill as belonging to a man of the River-drift period. With regard to the position of the implements found at Caddington and elsewhere, it should be remarked that the "contorted drift" there noticed is simply a disturbed surface of the brickearth or gravel, such as is often seen in the Thames Valley deposits. It has no connection with the Contorted Drift of the Cromer coast, nor has it been shown to have anything to do with the Chalky Boulder-clay. The author thinks "there can be little doubt of the former presence of floating ice here"; but soil-movements connected with freezing and thawing would have been quite adequate to produce the phenomena.

Chapter II contains an excellent account of "Ancient Cave-dwellers," and the author very properly remarks that "The whole question of the true or exact age of the older deposits of British and other caves is still more or less *sub judice*." At the same time he says "it is generally believed that Palæolithic man, and the extinct animals with which he is associated, lived here [in the north] when all our valleys, as far south as the Thames, were occupied by glaciers, and the higher grounds by snowfields." This is far from the case. The Boulder-clay, which is considered newer than some of the Cave-deposits in the north of England, is itself almost certainly newer than the Chalky Boulder-clay, which, occurring as far south as the Thames Valley, has been found at one place beneath the Thames Valley-gravel. In the previous chapter (p. 22) the author is inclined to take the view held by Prestwich, that the old river-gravels with Palæolithic implements were formed during the latest phase of the Glacial period; and recent evidence supports the view that the implements are newer than the Chalky Boulder-clay. Chapter III is devoted to "The Reindeer Hunters"; and then in Chapter IV we have the least satisfactory portion of the book, entitled "The Myth of the Great Ice Sheet, and Theories of the Flood." In this chapter the author's usually calm and considerate treatment of facts and opinions seems to have deserted him. He has evidently been upset by "The Glacial Nightmare and the Flood." Curiously enough he speaks in his Preface "of the clever special pleading of Prof. James Geikie and Sir Robert Ball," and now he follows the lead of "that valiant but most courteous fighter," Sir Henry Howorth! The idea of a great Polar ice-cap has been repugnant to some who are not simply critics, but observers of Glacial phenomena; yet the extent of ice in the Arctic regions now can hardly be considered as a test of that which may have been present during the Glacial period. The magnitude that has sometimes been assigned to old ice-sheets may be curtailed, but the facts of the extensive glaciation remain. It is well to remember that every view, when new, is apt to be somewhat exaggerated by authors and their disciples. Opinions differ with regard to the number and importance of milder inter-Glacial episodes, and also with regard to the actual extent of the maximum land-glaciation. If, however, in our interpretation of these Pleistocene phenomena, we had to choose between the most extreme of Glacial and the mildest of Diluvial hypotheses, we should have no hesitation in saying that the former was far more in accord with facts.

Happily our author is not led away into advocating any universal Deluge. He readily admits the evidence of glaciation, though not, apparently, to the extent that is generally taught and generally accepted. It is, however, not entirely easy to reconcile all his statements. He remarks that "land-ice in the form of glaciers is generally believed to have had more to do with forming the drift deposits than anything else." He admits "a modest local or British ice-sheet formed by confluent glaciers," and he gives an excellent description of

Boulder-clay. He fails to find any satisfactory explanation of the occurrence of Scandinavian boulders in our drift, and he tells us that Sir Henry Howorth has abandoned the notion that such stones were brought as ballast by the Vikings. Yet he uses most inconsiderate and exaggerated language when referring to the work and views of men like Agassiz, Ramsay, Croll, and James Geikie, when a calm and dispassionate view of vexed questions would have been far more appropriate. So much of what he says is good, and he appears so animated with the desire to present the truth, that his tirade is deplorable. Even the term "Great Ice Age" seems to have aroused the indignation of our otherwise temperate author; but the reader must pass by the uncomplimentary exclamations and pay attention to the facts.

With regard to the comparative nearness in time of the Glacial period, the author would date the ending of it to not more than 15,000 to 25,000 years—these are the rough limits he would assign to the antiquity of Man, and he says "the Palæolithic hunters were *certainly* here during the Glacial period." He thinks "It is ridiculous to suppose that the glacial striations in Wales or Scotland, to say nothing of moraines, etc., could have survived for so long a period" as Croll suggested—80,000 years. No doubt many striations have been effaced; others are preserved, and may be long preserved, beneath mantles of Boulder-clay. What, then, is the worth of such an argument? The author admits that civilized man appears to have lived in Egypt about 10,000 years ago. We must, therefore, be patient in awaiting further evidences before speaking with confidence on this vexed subject of Man's antiquity.

There is a curious slip on p. 144, where the author says: "Again, there are the high-level gravels, containing Palæolithic implements such as those of the Thames, to be seen at Hampstead Heath": we have never heard of any such discovery. And on p. 154, Dr. *Keith*, instead of Dr. *Hugh* Falconer, is mentioned. Such slips are, however, rare, and we may speak confidently of the careful way in which the author has given his facts and references.

The second part of his book deals with Men of the later Stone Age and Bronze Age; with lake-dwellings, kitchen-middens, barrows; with the science of fairy-tales and folklore, and with various megalithic monuments. The subject is treated in a full and pleasant style, and it will be read with interest and profit. The ten illustrations by Mr. Cecil Aldin are of a more sober type than those (previously alluded to in *Punch*) by Mr. E. T. Reed, and they are doubtless more true to nature.

III.—Geological Survey of Canada.—G. M. Dawson, C.M.G., F.R.S., Director. Annual Report (New Series): Vol. VII, 1894. (Ottawa: S. E. Dawson, 1896.)

HEREIN is described the great field of work in which the Canadian geological corps carried on their operations during the season of 1894, under their new Director, Dr. G. M. Dawson.

"The surveys," writes the Director in his summary report (pp. 1 A to 124 A), "consist of—(1) Reconnaissance surveys and explorations, covering in a general way large tracts of country; and (2) the systematic mapping and description in detail of less extensive areas. The first inevitably precedes the second class of work, and for many years it must, in the nature of things, remain the only method possible of dealing with the vast regions of Canada which lie beyond the boundaries of connected settlement." The distribution of the field parties was as follows: British Columbia, 2; North-West Territories (boring operations), 1; Keewatin District, 1; Ontario, 3; Quebec, 1; Labrador Peninsula, 1; New Brunswick, 1; Nova Scotia, 2: total, 12.

Experimental borings at Athabasca Landing, on the river of that name, favour the belief in the existence of a great petroleum-bearing region in the north-west; and it is suggested that if the oil could be supplied at a low price, it would be employed as a liquid fuel for railways in the North-West Territories and British Columbia. A large foreign demand might also be met from this region, such as that now supplied by the United States from their own resources to Japan and China.

The work done in British Columbia by Dr. Dawson and his two assistants, Messrs. McEvoy and McConnell, forms the subject of an extensive report on the area of the Kamloops map-sheet (pp. 1 B to 427 B). An interesting feature in this exploration was the examination of some important deposits of economic minerals, consisting of cinnabar, copper-ore (not very productive), and magnetic iron-ore. An inspection was also made of the property of the Van Winkle Hydraulic Mining Company, on the west bank of the Fraser River, about two miles above Lytton. The working of auriferous gravels in the higher terraces or "benches" of the Fraser, rising from the river in successive steps, is here being carried out by the hydraulic method. All the gravels here exposed are believed to be later Glacial or post-Glacial in age. No Boulder-clay is seen, nor is any true bed-rock reached. It is comparatively poor in gold. Hydraulic mining for gold is also carried on in the Cariboo district with apparently encouraging prospects. The importance of glacial action in relation to this alluvial gold-mining is insisted on, the superficial filling up of the valleys in which the gold is worked having resulted chiefly from the deposits and effects of the ice of the Glacial period. Dr. Dawson observes that "a much more general interest is being awakened in mining throughout the province, and it may be safely affirmed that British Columbia has now fairly entered on a period of rapid and thorough development of its mineral resources."

Under the heading of "General Geology" an outline of the main features of the formations met with in the area of the Kamloops sheet is given. These rocks consist of the following:—

			Feet.	
Early Pliocene?	... ...	Conglomerates.		
Later Miocene.	... ...	Volcanic rocks, largely basalt	3,100	
	Tranquille beds.	Bedded tuffs	1,000	
Earlier Miocene.	... ...	Volcanic rocks, largely porphyrites	5,300	
				9,400
Oligocene.	Coldwater Group.	Conglomerates and sandstones		5,000
Earlier Cretaceous.	Queen Charlotte Islands formation (chiefly).	Sandstones, conglomerates, and argillites		7,000
Triassic (and Lower Jurassic).	Nicola formation.	Chiefly volcanic; some limestones and argillites 7,500 to		13,500
Upper Palæozoic (chiefly Carboniferous).	Câche Creek formation.	In Western District. *Upper part.*—Marble-cañon limestone, with some volcanic rocks, argillites, and quartzites	3,000	
		Lower part.—Argillites, quartzites, and volcanic rocks, with some limestone	6,500	
				9,500
		In Eastern District. *Campbell Creek beds?*—Argillites and amphibolites ... ... about	5,000	
		Argillites and grauwackes, limestones and volcanic rocks	7,500	
				12,500
Lower Palæozoic (chiefly Cambrian).	Adams Lake Series.	Chiefly volcanic rocks, with some arkose conglomerate. Thickness actually observed in Kamloops sheet, 9,500 feet. Total thickness in adjacent Adams Lake section	17,100	
	Nisconlith Series.	Chiefly dark argillites. Thickness actually observed in Kamloops sheet, 2,000 ft. Total thickness in Selkirk Mountains section ...	15,000	
				32,100
		General Section of Kamloops Region		89,000

It is regarded as well within the limits of probability to estimate the volcanic materials of the interior plateau region of British Columbia at about 20,000 feet in total thickness. The width of this belt of volcanic rocks may be assumed to be about 100 miles. This vast extravasation must have been accompanied by enormous subsidences, which probably corresponded generally with the present position of the coast ranges. There were, however, recurrent periods of elevation which resulted in the production, at more than one period, of a chain of mountains along this line, which were

more than once carried away by denudation, until at the present day we find the existing mountains low in comparison with some of those of the further interior, but consisting for the most part of granitic rocks of deep-seated origin, with but scanty remnants of the older members of the Palæozoic series resting upon their flanks or remaining as infolds in their mass. Very often, and over large areas along the littoral of these ranges, the beds which rest directly upon the granites are of Triassic age; but from this it is not to be argued that the older formations have never existed there, for these may only have passed beyond recognition by entering as component parts into the subjacent granitic magma.

Under "Descriptive Geology" (pp. 79 B to 308 B) local details are entered into, and the data relied upon in laying down the geological lines discussed; these supplement the broad indications afforded by the map. Appendices follow: (1) upon the petrographical characters of some rocks from the area of the Kamloops map-sheet, by W. F. Ferrier; (2) Shuswap names of places, by Dr. G. M. Dawson; (3) upper and lower limits of growth of some trees and other plants as climatic indices; (4) comparative observations of temperature at different altitudes in or near the region embraced by the Kamloops sheet, southern interior of British Columbia, during parts of the years 1888, 1889, and 1890.

Mr. R. G. McConnell (Report, pp. 1 C to 40 C) was engaged during the earlier months of the year in working up the results of his exploration of the previous summer in the Finlay River and Omenica country, of northern British Columbia. The oldest rocks in the district are of Archæan age, and belong to the Shuswap series of Dr. Dawson. They consist of a series of well-foliated mica-gneisses, probably derived to a large extent from sheared eruptives, lustrous mica-schists, hornblende- and actinolite-schists, quartzose-schists, and crystalline limestones, filled with mica, hornblende, and other secondary minerals. The rocks of this series are usually evenly bedded, and are conformable with the overlying formations. Rocks consisting of slates, quartzites, and conglomerates, probably referable to the Lower and Middle Cambrian, are the next in succession. They have a thickness on the Omenica of about 4,000 feet. Grayish bedded limestones, holding corals, brachiopods, and other fossils characteristic of the Banff or Devono-Carboniferous division of the Bow River section, occur in the eastern ranges of the Rocky Mountains; while near the centre of the range, lower beds, probably Silurian in age, holding *Halysites catenulatus* were found in one place. Volcanic foliated schists and associated rocks, probably of Upper Palæozoic age, were found exposed along the Omenica. Triassic beds with *Monotis subcircularis* occur in the second range of the Rocky Mountains. Tertiary (Upper Laramie) beds, consisting of conglomerates interbedded with shales and sandstones, occupy the bottom of the valley of the Finlay. Some leaves and other plant-remains were yielded by the shales, and were determined by Sir J. William Dawson. The genera represented were *Arundo, Sequoia, Populus, Platanus, Quercus, Grewia* or

Grewiopsis (allied to *Tillia*), *Viburnum*, *Carpolite* (resembling *Leguminosites arachnoides*, Lesq.).

Evidences of glaciation abound throughout the district. In the Peace River Pass, well-marked groovings occur on the south side of the river, two miles east of Mount Selwyn. The movement of the ice here was eastward. The glacial deposits consist of Boulder-clay, accompanied by gravels, sands, and silts.

Gold has been obtained in the Omenica region, principally from the gravels overlying the older rocks, in the beds of the present streams. No deep diggings or extensive hydraulic workings have so far been attempted in this district.

Mr. D. B. Dowling presents his report (pp. 1 F to 54 F) on the country in the vicinity of Red Lake and part of the basin of Berens River, Keewatin. This district has an area of 6,300 square miles, the larger part of it forming a basin draining to the south to English River, and thence to Lake Winnipeg. The northern portion drains northward to Berens River, and thence westward to Lake Winnipeg. After detailing the physical features of the country, the writer describes its geological characters. The rocks exposed are all Archæan, consisting of gneisses and associated granites, classed generally as Laurentian, and folded schists and greenstones of the Huronian. In many respects these rocks are counterparts of those in the districts further south on the Lake of the Woods and Rainy Lake. Glacial action is shown in this area on the surfaces of the Archæan rocks, which are all more or less rounded and sometimes polished.

The report made by Dr. R. W. Ells (pp. 1 J to 157 J) treats of a portion of the province of Quebec comprised in the south-west sheet of the "Eastern Townships" map (Montreal sheet), with a chapter on the Laurentian, north of the St. Lawrence River, by Dr. Frank D. Adams. This is classic ground to the Canadian geologist, explorations having been carried on here almost from the beginning of the geological survey of Canada.

The sequence of the rocks (in descending order) represented in this region is as follows:—

Superficial deposits.
Devonian of Meniphremagog Lake.
Silurian of St. Helen's Island, Montreal, Lower Helderberg, and of the St. Lawrence Valley, presumably Medina.
Cambro-Silurian: Lorraine (Hudson River formation).
,, ,, Utica.
,, ,, Trenton and Black River.
,, ,, Chazy-Trenton, east of the Sutton Mountains axis, Farnham, etc.
,, ,, Chazy.
,, ,, Calciferous.
,, ,, Potsdam sandstone of the Ottawa and St. Lawrence basin.
Cambrian: Sillery red and green slates, sandstones, and grits. Black and grey slates, east and west of the Sutton Mountain anticline.
,, Georgia series of St. Armand (Lower Potsdam of the "Geology of Canada," 1863).
,, Lower Cambrian of the Sutton Mountain anticline.
Pre-Cambrian: Huronian of the Sutton Mountain anticline.
,, Laurentian limestone and gneiss, west of the St. Lawrence River.
Crystalline and igneous rocks, volcanic and plutonic.

Areas of Devonian rocks occur at several widely separated points east of the Sutton Mountain anticline and its extension northward. The only outcrops of strata holding typical Devonian fossils are found on the western shore of Memphremagog Lake.

The areas of Silurian rocks found in this portion of the province of Quebec are of limited extent. They comprise the basin in which the lower part of Lake Memphremagog is situated, which is probably the largest development of Silurian strata in south-western Quebec, and outcrops of very limited extent are found also on St. Helen's Island, Montreal, while in the flat country to the east of the St. Lawrence, and to the south-west of Becancour River, Silurian rocks of an older horizon occur. The structure of the Silurian in the eastern or Memphremagog Lake area is that of a folded basin, resting, on either side of the lake, upon fossiliferous Cambro-Silurian or Lower Trenton rocks. The rocks of the whole series have been subjected to great metamorphic action since their deposition, for they are highly inclined and folded, and also cut by numerous dykes, often of large size.

The complicated structure of the Cambro-Silurian rocks of south-western Quebec has given rise to much controversy, and its elucidation throws some light upon the much disputed question as to the age of the rocks of the city of Quebec, of the Island of Orleans (in the St. Lawrence below Quebec), and at many points along the Lower St. Lawrence, as also upon the age and equivalents of the fossiliferous Lévis and Sillery divisions of the Quebec Group. The district is traversed by extensive faults, among which is the great St. Lawrence and Champlain fault, described by Sir William Logan in the "Geology of Canada," which has been traced from the Vermont boundary, at the foot of Lake Champlain, to the city of Quebec, and thence down the St. Lawrence River along the north side of Gaspé Peninsula. The result of recent researches, in which palæontology has played an important part, is to show that the stratigraphical sequence of the various divisions of the Quebec Group, as interpreted by Logan, must be completely reversed, and the divisions must now be read upwards from Sillery (Upper Potsdam), Lévis, and lower Phillipsburg (Calciferous), upper Phillipsburg, Bedford, and Mystic (Chazy), and Farnham black slates and limestones (Lower Trenton).

The classification of certain areas in the south-western portion of the province as Cambrian rests, to a large extent, upon stratigraphical position and lithological characters, though in regard to the position of most of these rocks in the geological scale there can be no doubt. The rocks consist mostly of red and green and blackish-gray slates, and sandstones, which are quartzose in some places.

The pre-Cambrian rocks east of the St. Lawrence are represented in the Sutton Mountain range (an extension into the province of Quebec of the Green Mountains of Vermont), and at other places in this area described in Dr. Ells's report. The Sutton Mountain rocks consist of crystalline schists, which are gneissic, micaceous,

quartzose, and talcose in the central portions of the range, or that in which the axis of the anticline is situated; while the flanking rocks are green, chloritic schists; these extend from the Vermont boundary to the St. Francis in the vicinity of Richmond, and they are also recognized at various points on the eastern slope of the range.

Volcanic and plutonic rocks, including granites, syenites, diorites, dolerites, diabases, serpentines, traps, etc., evidently of different ages, are met with. They occur in low-lying outcrops, or they may rise into elevations, and constitute some of the most prominent mountains in the province of Quebec.

The Laurentian area in the north-west corner of the sheet comprising Dr. Ells's report is described by Dr. F. D. Adams. It forms a portion of the southern margin of the great northern "protaxis" of the continent, and thus represents a part of an extremely ancient land area, from the waste of which the clastic Palæozoic strata to the south were derived. The area here described, amounting only to about 400 square miles, is about equally divided between the rocks of the Laurentian system and intrusions of anorthosite which break through them.

The Laurentian consists of red and gray orthoclase gneisses, presenting great variations both in structure and composition, with which are associated crystalline limestones, quartzites, and amphibolites. Certain parts of the area can be recognized as belonging to the "Grenville series" of Sir W. E. Logan. This consists typically of an upper series of crystalline limestones, quartzites, and gneisses, having the chemical composition of ordinary sediments and a preponderating banded structure. There is also a lower series of gneisses, in which there are no limestones, etc. The latter is known as the Fundamental Gneiss, and it is this which is probably represented in the region described by Dr. Adams. Breaking through the gneisses are four masses of anorthosite, which are now known to be intrusive. Although intruded through the Laurentian at a time long preceding the Potsdam, the appearance of these anorthosites antedated at least the termination of the great earth-movements which affected the Laurentian in pre-Potsdam times, so that they have been squeezed and foliated together with the gneisses through which they cut. On the upturned edges of these deeply eroded Archæan rocks, both gneiss and anorthosite, the Potsdam sandstone and other Cambro-Silurian rocks repose in flat and undisturbed beds.

A voluminous Appendix by Dr. H. M. Ami, Assistant Palæontologist, concludes Dr. Ells's report. The Appendix contains preliminary lists of the organic remains occurring in the various geological horizons referred to in the report. Short descriptive notes on some of the fossils enhance considerably the value of these lists, and testify to the experience and assiduity of their compiler.

Mr. Robert Chalmers' report (pp. 1 M to 149 M) on the surface geology of eastern New Brunswick, north-western Nova Scotia, and a portion of Prince Edward Island, contains a detailed account of this area, which is described as "one of the most interesting and

important fields of investigation to be found in Eastern Canada, both as regards its surface geology and its agricultural resources." Attention is naturally devoted in this report to glacial phenomena of all kinds, the data demonstrating the existence and action of floating ice in the Pleistocene are summed up, and changes of level during the later Tertiary and post-Tertiary periods investigated. The physical features of the Bay of Fundy with its remarkable tides are discussed, and their origin explained. The account of the Boulder-clay and boulders is followed by a long list of glacial striæ with their bearings and elevations. The latter are illustrated in plates ii, iii, and iv. (Plate i has been left out and plate iii duplicated.) The author traces out local Pleistocene glaciers in the Baie des Chaleurs, the St. John River Valley, and the isthmus of Chignecto; and, summarizing his results, finds that at the period of the maximum extension of the ice, there was a general radial movement from the main nevé ground of the north-east Appalachians, northward and eastward into the St. Lawrence Valley, eastward into the south-western embayment of the Gulf of St. Lawrence, south-eastward into the Bay of Fundy and Atlantic Ocean, and southward and south-westward into United States territory. The occurrence of peat-bogs, dunes, and salt-marshes is noted, and a description given of them. Two sketch-maps showing (in colour) the areas occupied by Pleistocene glaciers, and the striation from local glaciers and floating ice, accompany the report.

Dr. G. Christian Hoffmann (pp. 1 R to 68 R) reports upon the section of Chemistry and Mineralogy, while the division of Mineral Statistics and Mining for the whole Dominion is embodied in Mr. E. D. Ingall's report for 1893 and 1894 (pp. 1 S to 187 S). The bulk of this last report is sufficient evidence of the great efforts now being put forth for the development of the mineral wealth of the Dominion.

Maps (eleven in all) of parts of British Columbia, Quebec, New Brunswick, and Nova Scotia, and Prince Edward Island, illustrating the reports of those regions, are issued with the volume, at the end of which there is a good index.

Dr. Dawson and his coadjutors may well be congratulated upon this valuable addition to our knowledge of the geology of the Canadian Dominion. ARTHUR H. FOORD.

IV.—AN INDEX TO THE GENERA AND SPECIES OF THE FORAMINIFERA. By C. D. SHERBORN. Part II: NON to Z. (City of Washington: Smithsonian Institution, 1896.)

THIS is No. 1031 of the "Smithsonian Miscellaneous Collections," and completes C. D. Sherborn's Index of the Foraminifera, of which the First Part was published in 1883, through the liberality of the Smithsonian Institute. The dates of the writers on recent and fossil Foraminifera and their multitudinous, often confused Nomenclature, referred to in this elaborate Index, range from about 1565 to 1889. Already, in the GEOLOGICAL MAGAZINE, Mr. Sherborn's careful and

valuable Bibliography of the Authors was noticed in January, 1889; and the First Part of the still more elaborate Index in August, 1894.

The two Parts, in 429 pages, contain at least 20,000 published names of the genera, species, and noticeable varieties of Foraminifera; and pages 480–5 are full of additions and critical corrections, due in great part to the enthusiastic research and kind help of Mr. F. W. Millett, of Marazion. This friendly aid, as well as the assistance given by other sympathizers in this important work, is thankfully and cordially acknowledged by the author in the Introduction to Part II.

A general idea of the value of such a synoptical and alphabetical catalogue of the multitudinous names given to these microzoa—often duplicate or triplicate, and to be found, in many instances, only in some rare or obscure periodical—can certainly be formed by any biologist, after even a short consideration of the circumstances. In actual experience, however, a monographist, desirous to do full justice both to species and species-makers, can estimate its real value by the saving of time and labour, which would have had to be spent in various libraries, often far apart, whilst hunting up references, often dubious and disappointing, and following professed clues, whether to real, or probable, or merely possible good results, or to the desiderated author or species.

Like the rest of Mr. C. D. Sherborn's bibliographic work, this Index is industriously complete and conscientiously exact, as far as circumstances have permitted. It is to be hoped that Mr. Sherborn, either by himself or with others, will carry on his work of ploughing up this wide field of nomenclature, and turn up both the rich soil and the troublesome clods, old and new, ready for the student, and open to the light of criticism.

V.—The Detection and Measurement of Inflammable Gas and Vapour in the Air. By Frank Clowes, D.Sc., etc. With a Chapter on the Detection and Measurement of Petroleum Vapour, by Boverton Redwood, F.R.S.E., etc. 8vo, pp. xii and 206, one plate and 49 diagrams. (London: Lockwood and Son.)

COAL and petroleum are of great interest to the geologist in many ways, and have been carefully studied as to their natural occurrence, their probable origin, their special localities, the means by which they are obtained, and the methods of their use: and geologists have had much to say on these points. Of course, the combustibility of coal and petroleum give these substances their peculiar value to the world at large; and, on account of the dangerous explosive powers of their derivative gases and vapours, these latter have had to be carefully studied by chemist and physicist.

The best methods of determining the presence of such gases in the air is the object of this book, which gives a carefully considered resumé of what has been done in this line of research. The inflammable gases concerned are Methane (Marsh-gas or Fire-damp), Coal-gas, Water-gas, Hydrogen, Carbonic Oxide (Choke-damp), Ethylene, and Acetylene; and their conditions of explosion

when mixed with air are first of all stated; also the influence of dust on the explosibility. Then follows a historical summary of methods of gas-testing used in coal-mines, more particularly by "test-flame" and "flame-cap," whether with oils, alcohol, or hydrogen. The hydrogen-flame, however, is considered to give the best results. It has, indeed, been found practicable to introduce it into an oil safety-lamp, so as to supply a "standard flame" and its distinct "flame-cap"; and to supply a light even when the oil-wick fails to burn. It is specially adoptable for testing the coal-bunkers on board ship, which are so often the source of destructive fires and explosions. Test-chambers and other apparatus for experimenting with flame-tests on known and unknown mixtures of air and gases are fully explained and illustrated.

Amongst the combustible gases carbonic acid is here included; and Dr. Haldane's researches on the poisonous properties and the detection of this gas (carbon-monoxide) are summarized (pp. 130–145). Carbonic acid gas (carbon-dioxide) is also dealt with, as often present with combustible gases, and as being a product of their burning or explosion.

A very important chapter follows on the detection and measurement of the vapour of petroleum in the air (by B. Redwood), pp. 168–197; particularly in the steamers carrying petroleum in tanks, and in the holds of vessels carrying or that have carried casks of petroleum.

A classified bibliography of papers relating to the subject of this useful book is added (pp. 198–200), and an index is appended.

T. R. J.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—December 2, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "Another Possible Cause of the Glacial Epoch." By Professor Edward Hull, LL.D., F.R.S., F.G.S.

In the introductory portion of the paper the author gives an account of the submarine topography of the area east of North America, and summarizes Dr. J. W. Spencer's work upon a submerged Antillean continent; he then deals with the effects which would be produced upon the Gulf Stream by the uprising of this continent in the Glacial Period, and maintains that, as the current could not pass into the Gulf of Mexico (being debarred by a coast of high continental land), it would flow directly northwards into the North Atlantic, and thereby be deprived of about 10° (Fahr.) of heat: the effects of which may be practically illustrated by supposing the isothermal line of 32° to take the place of that of 42° in the northern hemisphere. He argues that the increased snowfall which would thus be caused over certain areas would tend to intensify the cold through all the adjoining tracts.

To the effects produced in this way must be added those due to

the elevation of the land of Eastern North America and to an elevation of North-Western Europe, which is supposed to have occurred at the end of Pliocene times. These elevations would intensify the glaciation caused by the difference of direction taken by the Gulf Stream.

2. "On the Affinities of the Echinothuridæ, and on *Pedinothuria* and *Elikodiadema*, two new Subgenera of Echinoidea." By J. W. Gregory, D.Sc., F.G.S.

The author summarizes and discusses the literature bearing upon the Echinothuridæ, and brings forward arguments to prove that the family is a member of the order Diademoidea, and is derived from the Pedinidæ, members of which are found in earlier rocks than the Corallian, which contains the oldest member of the Echinothuridæ, namely, *Pelanechinus*. He maintains that the extreme flexibility and loose articulation of the plates of the living genera *Asthenosoma* and *Phormosoma* are due to the diminished calcification of the plates, and that these recent genera are extremely specialized forms, and not primitive—the apparently primitive features of the family being secondly acquired, not primæval.

A description is given of forms belonging to two new genera, described as *Pedinothuria*—a connecting-link between the Pedinidæ and Echinothuridæ; and *Elikodiadema*—which has a flexible test, is a modified form of *Pseudodiadema*, and has probably arisen from the adoption of a deep-sea life resulting in diminished calcification of the test.

3. "On *Echinocystis* and *Palæodiscus*, two Silurian Genera of Echinoidea." By J. W. Gregory, D.Sc., F.G.S.

The author gives a history of the genera *Echinocystis*, Salter, and *Palæodiscus*, Wyv. Thoms., redescribes their structures, and discusses their affinities. He concludes that *Echinocystis* is an echinid and not a cystid; and that *Palæodiscus* is an echinid and not an asterid. In order to prevent confusion, he suggests the name *Scolocystis* for a true cystid which was described by Hall as *Echinocystis*, some years after the latter name had been applied by Wyville Thomson to the fossil now concluded to be an echinid; and also suggests the name of *Discocystis* for the form named *Echinodiscus* by Worthen and Müller.

In discussing the affinities of *Echinocystis*, Wyv. Thoms., the two latest diagnoses of the Cystoidea (those of Professor von Zittel and Professor Haeckel) are considered, and it is contended that they do not enable us to draw any sharp line of distinction between cystids and echinids.

It is shown that the masticatory apparatus of *Palæodiscus* and *Echinocystis* explains the origin of that structure in gnathostomate echinids; and furthermore, it is suggested that *Echinocystis* renders probable the homology of the so-called "calycinal plates" of the Echinoidea with the plates of the valvular pyramid of the Cystoidea, and not with the calyx-plates.

The author gives synopses of the order Cystocidaroidea of Prof. von Zittel, and of its two families, Palæodiscidæ and Echinocystidæ.

II.—December 16, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Subdivisions of the Carboniferous Series in Great Britain, and the True Position of the Beds mapped as the Yoredale Series." By Dr. Wheelton Hind, F.R.C.S., F.G.S.

In this paper the author gives a summary of our knowledge of the local divisions of the Carboniferous system, and criticizes the present classifications in vogue, laying special stress upon the local variations in the lithological characters of the rocks, and summing up to a large extent the fossil evidence which is available. He maintains that the Yoredale Beds are largely the equivalents of the beds which have elsewhere been referred to the Mountain Limestone Series, though some local beds which have been included in the Yoredale Series may rather be the equivalents of the Millstone Grit. He advocates the abolition of the term "Yoredale Series" as applied to a subdivision of the Carboniferous strata comparable in importance to such divisions as Carboniferous Limestone and Millstone Grit, but believes that the term may be usefully employed to denote the changes in character of the beds due to causes which operated locally, and to represent the Carboniferous Series as it occurs in Wensleydale, Swaledale, Teesdale, and the upper parts of Wharfedale and Ribblesdale.

He would divide the rocks of the Carboniferous system into an Upper Carboniferous or Anthraciferous Series, and a Lower Carboniferous or Calcareous Series; and indicates the occurrence of three very different faunas in the Carboniferous rocks, viz.: (i) a Coal-measure fauna rich in fish-remains, with the molluscan genera *Carbonicola*, *Anthracomya*, and *Naiadites* (essentially a fresh-water fauna); (ii) the Lower Coal-measure and Grit fauna, largely marine but littoral, with *Aviculopecten*, *Posidonella*, *Nautilus*, *Goniatites*, and peculiar gasteropoda; and (iii) a Limestone fauna essentially marine, very rich in brachiopods, and containing *Pecten*, *Avicula*, *Edmondia*, *Sanguinolites*, and many other lamellibranchs, gasteropods, such as *Euomphalus*, *Pleurotomaria*, *Murchisonia*, and *Loxonema*, and certain peculiar cephalopods.

2. "Notes on Volcanic Bombs in the Schalsteins of Nassau." By Professor E. Kayser, Ph.D., For. Corr. G.S. (Communicated by the Secretary.)

The bombs forming the subject of this communication occur in two localities in the neighbourhood of Oberscheld, near Dillenburg. They are generally rounded, though sometimes angular, and vary in size from that of a nut to that of a man's head. Each consists of a kernel of coarse-grained rock representing a fragment of limestone altered by metamorphism, surrounded by a rind of amygdaloidal rock due to the inclusion of the fragments in molten lava. They demonstrate the pyroclastic origin of the Schalsteins, and also prove the similarity between the old Devonian volcanoes and those which are now active.

III.—January 6, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read :—

1. "On the Structure of the Skull of a Pliosaur." By C. W. Andrews, Esq., B.Sc., F.G.S.

The paper deals with a specimen of the Plesiosaurian known as *Pliosaurus ferox*, Sauvage, obtained by Mr. A. N. Leeds from the Oxford Clay near Peterborough, and now in the British Museum, and perhaps the finest Pliosaur skull known. It bears a great similarity to *Peloneustes philarchus*, but there are a number of differences which tend to show that the subject of the present communication is not the skull of an old individual of *Peloneustes*. Although the teeth of the fossil here described agree precisely with those described by Sauvage from the same horizon at Boulogne under the name *Liopleurodon ferox*, they differ considerably from those of the Kimmeridge Clay upon which Owen founded the genus *Pliosaurus*; they, however, show a distinct tendency towards the typical form, and since the skull and skeleton of the Oxfordian and Kimmeridgian forms are, so far as known, closely similar, the author prefers for the present to follow the British Museum Catalogue in referring them both to one genus, *Pliosaurus*.

The author gives a detailed description of the skull which forms the subject of the paper.

2. "On the Pembroke Earthquakes of August, 1892, and November, 1893." By Charles Davison, Sc.D., F.G.S.

Part I of this paper deals with the earthquakes of August, 1892, of which eleven are recorded, the principal being the third. The author gives an account of the preliminary shocks and after-shocks, and a detailed account of the principal earthquake, describing the disturbed area, the relationship of the earthquake to a north-and-south fault, hading to the west, that of sound to shock, and the occurrence of sea-waves.

Part II treats of the earthquakes of November, 1893; there were four undoubted earthquakes, of which the first was the chief one. Descriptions are given of the phenomena.

Part III treats of the origin of the earthquakes and their connection with faults; and the author points out the possible value of the study of earthquakes in supplementing geological surveys. For more than fifty years prior to the earthquakes of 1892–3 there appear to have been no slips of importance along the fault-system of the area. After this prolonged interval of repose, the earlier movements took place along transverse (north-and-south) faults, and the later along longitudinal (east-and-west) ones. The three faults of the latter series which the author connects with the disturbances lie successively one to the north of the other, as if the abrupt displacement of a rock-mass over one thrust-plane impelled the advance of those immediately below. There can be little doubt that the fault-slips of 1892 affected the conditions of stress along the neighbouring transverse fault, so that the displacements along it occurred earlier than they might otherwise have done.

3. "Changes of Level in the Bermuda Islands." By Professor Ralph S. Tarr. (Communicated by the Secretary.)

The author gives a summary of previous writings bearing upon the geology of the Bermudas; but his own researches point to a rather more complicated series of changes than those which have been inferred by other writers. The formation of the "base-rock" or "beach-rock" occurred at some period which cannot be accurately ascertained at present, owing to the fragmentary nature of the included fossils. It may have been formed in Pleistocene or even late Tertiary times. After its formation it was converted into a dense limestone and then eroded, probably by subærial agents, and finally attacked by the waves at an elevation of at least 15 feet above present sea-level; during this stage it was covered by beach-deposits of pebbles and shells, which were accumulated in a period so recent that the contained fossils are of the same species as the organisms living in the neighbouring sea. Then followed an uplift, during which land-shells lived on the beach-deposits; but these were soon covered by blown sand, the principal accumulations of the islands, and the outline of the islands was perfected by the action of the winds. This was done at an elevation which was at one time certainly as much as 40 or 50 feet above present sea-level. The author adduces evidence of a depression since the accumulation, causing land to disappear and the outline of the area to become very irregular; and he proves that these changes cannot be accounted for solely by erosion, as some have maintained. There are indications that the land is at present quiescent. It appears, then, that most of the work of construction of the Bermudas has been done in recent times.

CORRESPONDENCE.

INDICATIONS OF EARTHQUAKE.

Sir,—The accounts of the recent earthquake which I have seen in an English paper, include references to the accompanying sound as resembling the noise "of a rushing wind." This recalls an observation of my own showing that the appreciation of such sounds varies at times from the subterranean or other rumblings so often recorded.

It was early in the seventies when I was reading over the fire one night in my "den" at Devonshire Cottage, Murree, elevated about 7,000 feet on the foot-hills of the Punjab outer Himalaya. The fire had burned low in a grate surmounted by an arch cut from a sandstone slab, which was cracked upwards from the crown, and for more warmth I had placed my feet against the slab on each side of the crack. A little later I noticed a "soughing" or sound of "rushing wind," as I thought, coming up the valley from Trêt, through the pine forests. Thinking this strange on a calm night I looked up and over my book, when I distinctly felt the motion of one of the small earthquakes not very uncommon in the Upper Punjab, and saw the old crack referred to open between my feet for more than half an inch, and close as the seismic wave passed onwards.

It may be this which fixed the character of the sound in my memory; at any rate, I do not recollect another earthquake accompanied by the sound of "rushing wind."

Davas Darf, Suisse,
December 19, 1896.

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DR. WHEELTON HIND'S CARBONIFEROUS LAMELLIBRANCHIATA.—PART I. INTRODUCTION (PALÆONTOGRAPHICAL VOLUME, 1896).

SIR,—Under the heading of "General Sequence of the Carboniferous Rocks," which embraces analyses or divisions of some of the coalfields in Britain, reference is made to the succession of the rocks in the Coal-measures in Somersetshire, or the southern part of the Bristol Coalfield. *Under* the general term Coal-measures, in the division "UPPER," are placed—(1) The *Radstock and Farringdon* Series; (2) The *New Rock and Vobster* Series: both these are classed as belonging to the *Upper* Group of Coals.

The Radstock and Farringdon Series are undoubtedly members of the Upper Coal-measures, and of the uppermost division in Somersetshire; but the *New Rock* and *Vobster Series*, or coals, are in the *lowest* part of the *Lower Coal-measures*,—the two series being separated by *nearly* 2000 *feet* of the well-known "*Pennant* Sandstone," so that the *term Upper* is here most misleading. Between the lines Radstock and Farringdon Series, should be inserted the "MIDDLE or PENNANT SERIES, or *Sandstones*" (2000 feet thick). The term "Millstone Grit" has no value here, unless the *New Rock* and *Vobster Series* (coals) are inserted below the Pennant and above the Millstone Grit, in the *Somersetshire* portion of the Bristol Coalfield, the northern and southern areas forming one continuous field. We can hardly understand how the northern and important division of the Bristol and Somerset Coalfield was omitted in the sequence. The entire basin is 26 miles from north to south, and 8 to 10 miles from west to east, but continuous and almost unbroken, the sequence being the same in either case, the Carboniferous Limestones and coal shales being highly fossiliferous. The Bristol Coalfield is the most typical and perfect in stratigraphical succession of any of the coalfields in Britain. I draw Dr. Wheelton Hind's attention to this very important omission in order that he may make his monograph upon the fossils of the British Carboniferous rocks for the Palæontographical Society as complete and accurate as possible, and that he may be induced to look carefully into the true succession of the different areas that will come under his examination.

R. ETHERIDGE.

OBITUARY.

DAVID ROBERTSON, LL.D., F.L.S., F.G.S.

BORN NOVEMBER 28, 1806. DIED NOVEMBER 20, 1896.

DAVID ROBERTSON, once upon a time the little herd-boy of a Lanarkshire moorland farm, by-and-by the successful Glasgow merchant, and then for thirty or forty years the keen, shrewd, patient observer, bent on the acquisition and furtherance of "natural knowledge," has passed away, after a life that has still been "too short for friendship," although so greatly prolonged. He was born in 1806, November 28 of the Old Style; he died in 1896, November 20 of the New Style, and therefore just within three

weeks of finishing his ninetieth year. It must not be fancied from his age that his claim to be noticed in this Magazine depends on his having become, as is sometimes the result of longevity, a breathing fossil. On the contrary, his scientific activity was maintained unflinchingly to the end. He became a Fellow of the Geological Society of London in 1869, but he had joined the Geological Society of Glasgow two years earlier. To the Quarterly Journal of the former he contributed but one short paper; to the Transactions of the latter a long series of Essays, many of them in collaboration with the late Dr. Crosskey on post-Tertiary Clays. Together with G. S. Brady and Crosskey, he compiled for the Palæontographical Society an important Monograph on the post-Tertiary Entomostraca of Scotland.

In the words of Mr. Dugald Bell, Robertson's work in geology was distinctively that of a zoologist, but characterized, like all his other work, by its minute and painstaking thoroughness. "He seldom, if ever, meddled with questions of stratigraphical or physical geology. In conversation he sometimes 'beat over' certain points in glacial geology, and his statement of doubts and difficulties here and there was always very suggestive. But he always fell back upon his labours to unfold the *life* of the period as far as possible, in all its varieties, even the humblest. The principal observations of a more general kind, relating to what may be called physical matters, which I remember as coming from him, are (1) his note on the accelerated precipitation of sediment in salt-water as compared with fresh; and (2) his remark that a lighter or browner colour of the Upper Boulder-clay, as compared with the Lower, was due very frequently at least, not to any difference in materials or in conditions of deposition, but simply to the action of the weathering agencies to a certain depth from the surface on the ferruginous elements contained in the clay. These observations were wrought out with great clearness, and have been very helpful in some points." (Mr. Dugald Bell *in litt.*)

From 1892 onwards Robertson was on a Committee of the British Association for investigating certain shell-bearing clay deposits in various parts of Scotland. When a man of eighty-six is placed on such a committee, it might well be supposed to be done out of pure compliment, or for the countenance of a distinguished name, or at most to add the authority of an experienced judgment to the results of younger men's labour in the field. A far different view of the responsibility was taken alike by those who selected Robertson, and by the man of their choice. Each year a substantial part of the report has been from his pen. Each year a substantial part of the work has been accomplished by his exertions. He undertook the preparation of the samples of clay, and the determination of the various organic remains, many of them extremely minute or fragmentary, which resulted from the careful washing, straining, and separating of the constituent gravel, sand, and mud. The tediousness of the occupation none can know but those who have tried it. In private correspondence Robertson would speak of the